THE PROGRESSIVE FISH CULTURIST

NEWS AND VIEWS FROM MANY SOURCES ON PRACTICAL HATCHERY PROBLEMS

ISSUED BY THE

BUREAU OF FISHERIES, U. S. DEPARTMENT OF COMMERCE

AUGUST - SEPTEMBER 1938

WASHINGTON

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THE PROGRESSIVE FISH CULTURIST

A SERIAL memorandum published occasionally for the advancement of Federal, State, and private fish culture and fishery management in fresh waters.

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BUREAU OF FISHERIES, U. S. DEPARTMENT OF COMMERCE

Memorandum I-131 Washington, D. C., August-September, 1938 No. 40.

THE DEVELOPMENT OF A BONY FISH

By Archie Norman Solberg

Department of Biology, University of Toledo, Toledo, Ohio

VERY FEW PERSONS are familiar with the development of bony fish because this group is usually not studied in college courses in embryology. Consequently, anyone who wishes to investigate certain phases of the development of a fish must go to the original papers that have been written. Perhaps the best description that has been made was by H. V. Wilson (1889) on the Sea Bass. His descriptions are very good but perhaps so detailed that, to anyone not familiar with the subject, the material is difficult to read and his figures difficult to interpret.

The following is a general description of the development of a bony fish, illustrated with photographs made through a microscope and drawings, designed to acquaint the reader with a knowledge of the important changes that are involved as an egg develops into a young hatched fish. Attention will be paid especially to the changes that are visible in the photographs and may be seen in living eggs through a microscope.

The fish upon which this work has been done is called the killifish (Fundulus heteroclitus), a marine minnow that occurs in large numbers along the Atlantic coast. This fish was selected because the eggs are readily available during the months of June and July when I was able to study them. Following the development of living eggs requires a considerable amount of patient watching because the changes that occur continue through both night and day. Several times I have observed and photographed

eggs at hourly intervals over several day periods. To date I have taken over eight hundred photographs of the developing embryos of this fish. I wish to acknowledge the assistance I have had from Margaret Solberg and Sam Schall.

OBTAINING THE EGGS

All of the eggs were obtained at the Marine Biological Laboratory at Woods Hole, Massachusetts. The collecting department of the laboratory catches the mature fish in large nets and brings them to the laboratory where they are placed in running sea water aquaria. The fish will spawn in the aquaria if a single female and several males are placed in a tank (Newman, 1907), but the eggs may be more easily obtained by stripping. I used the latter method exclusively. The sexes are easily distinguished during the breeding season. The females have a pale color, distended abdomens, and thick anal fins; whereas the males have a bright color, large anal and dorsal fins, and a dark pigmented spot on the dorsal fin.

When eggs were desired, a female with a distended abdomen was selected. By gently squeezing her body, the eggs were stripped into a glass finger bowl containing about enough sea water to barely cover them. A healthy male was then stripped of his milt, over the eggs, and the whole was gently stirred. After allowing 15 minutes for the eggs to fertilize, the excess milt was washed away and the eggs distributed into glass finger bowls with not more than fifty eggs per bowl.

In order to make certain that the eggs developed at a constant rate, the bowls were placed in a constant temperature bath in which the temperature was controlled by a mercury thermo-regulator so that it varied less than 1/100th of a degree Centigrade. The eggs were kept in this bath from the time that they were stripped. All sea water used had been previously brought to the temperature of the bath. The eggs described here were developed at 25° C. (77° F.), but other series have been run at 20° C., 17.5° C., and 12.2° C. The rate of development is correspondingly slower at lower temperatures. Fundulus eggs have a temperature tolerance, without producing more than 2% abnormalities, of from 12° C. to about 26 or 27° C. To insure sufficient oxygen, the water was changed twice daily.

The photographs were taken with a Leica camera using an Ibso attachment with a 6x eye-piece and a 32 mm. objective on the microscope. Transmitted light from a 200 watt bulb in a Spencer microscope lamp was used for illumination. The pictures were enlarged for study.

STRUCTURE OF THE EGG

The eggs of Fundulus heteroclitus are a little more than 1/16 of an inch (2 mm.) in diameter and are covered by two membranes. The innermost is called the vitelline membrane or fertilization membrane since it normally is not visible until after the egg is fertilized. The outer membrane is a tough shell-like chorion which is produced in the ovary of the female by follicle cells surrounding the egg during its formation. This chorion is a protective membrane, and attached to it are a large number of uniformly distributed silky adhesive threads, also produced by follicle cells. These threads become sticky after they have been in sea water for an hour or more. They hold the eggs to rocks and weeds in the ocean, but they are a distinct nuisance in the laboratory since they cause the eggs to clump and collect dirt

so that the center eggs often suffer from lack of oxygen. The adhesive threads were undisturbed in the photograph of the one hour egg. In all of the others, however, most of the threads were removed by pulling them off with a fine forceps.

The egg proper consists of a large mass of nearly transparent yolk containing a large number of small oil drops. The oil drops are visible in all of the photographs but have not been included in the drawings. The "living" portion of the egg consists of only a thin layer of cytoplasm, containing a nucleus at one side, surrounding the mass of yolk and oil drops. This is the condition of the egg when it leaves the ovary of the female. Within a short time important changes take place which begin the process of development of the embryo. These changes begin with the entrance of the sperm, the active element of the milt of the male.

FERTILIZATION

Both the egg and the sperm are active living cells, but neither one can develop into an embryo until they have been combined in a process called fertilization. We usually describe fertilization as the act of the sperm entering the egg.

The sperm is a motile cell and swims about in the sea water until it comes in contact with an egg. The sperm must enter the egg through a small opening, called a micropyle, in the chorion covering the egg. The micropyle is a funnel-shaped structure, very difficult to see in Fundulus eggs. (See drawing of unfertilized egg.) As soon as a sperm reaches the micropyle it starts to pass through. Slowly the egg receives the head of the sperm, taking it right into its cytoplasm. Then the sperm tail drops off and gets lost in the adhesive threads on the chorion. The head of the sperm contains the nucleus of the sperm cell, and the nucleus of the egg is located just beneath the micropyle. After the egg has completely "matured" the two nuclei combine to form one nucleus, completing the process of fertilization.

Immediately after the penetration of the egg by the sperm, the egg shrinks slightly leaving the vitelline membrane in contact with the chorion. This leaves the egg free to rotate inside the chorion, a phenomenon easily demonstrated in living eggs.

BEGINNING OF DEVELOPMENT. CLEAVAGE AND FORMATION OF THE BLASTULA.

Fertilization initiates development. After the artificial insemination of the eggs as already described, the sperm enters within a few minutes, and development begins soon thereafter.

When fertilization begins, the main living portion (cytoplasm) of the egg is distributed in a nearly uniform layer around the yolk. After fertilization the cytoplasm streams toward the side of the egg on which the nucleus is located, making a distinct cap of cytoplasm usually called the polar cap. The cap forms in an hour after fertilization. (See 1 hour drawing and photograph.)

Since the egg is still only one single cell at this time, the first step in development consists of splitting this polar cap into two cells, each with its own nucleus and bit of cytoplasm. This process of cell division is called cleavage because the polar cap is cleaved into smaller and smaller cells with only a minimum amount of growth during the process.

The first cleavage division makes two cells. (See photograph and drawing of egg at 1½ hours.) The division cuts only through a portion of the cytoplasm, but the nucleus divides completely. This takes 1½ hours from fertilization. Within another half hour these two cells have each divided again to make four cells (2 hour egg); and again in still another half hour, the division of each of the four cells makes eight cells into which the polar cap has been cut. These eight cells are usually arranged in two rows of four cells each, as seen in both the drawing and photograph of a 2½ hour egg. The divisions continue until there are 16 cells (3 hour egg), then 32 cells (3½ hour egg), 64 cells (4 hour egg), and so forth (4½ hour egg). By the time there are 64 cells, they have become so small and so piled up on one another that we seldom attempt to count them after that. The cells mass is then called the blastoderm. Up to this time the cells have all divided at the same time (synchronously), but after 128 cells are formed the divisions become irregular so that in any one instance the number of cells may be an odd number and not some multiple of two.

At the same time that the cells have been cleaving important changes have occurred internally. Beginning at the eight cell stage, the central cells become free from the underlying yolk. Their separation forms a cavity, filled with fluid, which is called the blastocoele. After about the 128 cell stage, when we no longer can identify the exact number of cells, the embryo is called a "blastula", or is said to have developed to the blastula stage. This stage is a long one in Fundulus embryos, lasting from five hours to sixteen hours. Certain changes in shape and size of the cells occur during this period by which the approximate age can be determined. The cells continually decrease in size. Changes in shape are also easily seen. The blastoderm is high, like the original polar cap, during the early blastula stages (5½–9 hours). During the period from 10 to 12 hours it begins to flatten without increasing in diameter but by the sinking of the cells into the yolk. Then, beginning at about 13 hours, the blastoderm begins to expand, still remaining closely adhered to the yolk.

GASTRULATION AND THE BEGINNING OF THE EMBRYO

The expanding of the blastoderm is followed by the beginning of a process called gastrulation. Starting at 16 hours, the cells at one edge of the blastoderm become free from the surface of the yolk (periblast) and begin to turn under, rather than slide over the yolk. Meanwhile, in every other part of the blastoderm, the expanding continues. The location of this inturning (involution) of cells is called the dorsal lip of the blastopore because of its correspondence with the same structure in the developing amphibian embryo. The surface of the blastoderm, under which these cells have turned, thickens to mark the location of the future embryo and is called the embryonic shield. (See drawings and photograph of 17 hour embryo.) The inturned cells also are going to form very definite parts of the embryo. The tissue is called the primitive endoderm (see section of 17 hour embryo), and it later gives rise to most of the internal organs.

The formation of the embryo continues during gastrulation. The blastoderm continues to grow over the yolk sliding right over the equator of the egg and on to the opposite side from which it started.

Shortly after the germ ring passes the equator another structure makes its appearance, called the keel. This structure is formed as a thickening of cells in the center of the long axis of the embryonic shield. The keel will form the central nervous system and part of the eyes.

Only that part of the blastoderm that lies in the location of the embryonic shield will form the embryo, the remainder forming the yolk sac, an organ which persists only until the yolk is used up. The part of the yolk which is still not covered by yolk sac is called the yolk plug. The continued growth of the germ ring results in the closure of the blastopore of which no trace is left. It was formerly thought that the embryo was formed in part at least by the right and left halves of the germ ring, by their coming together (concrescence) during the closure of the blastopore, but such a theory has been discarded since Oppenheimer (1935) showed that it was not true.

THE PRIMARY GERM LAYERS

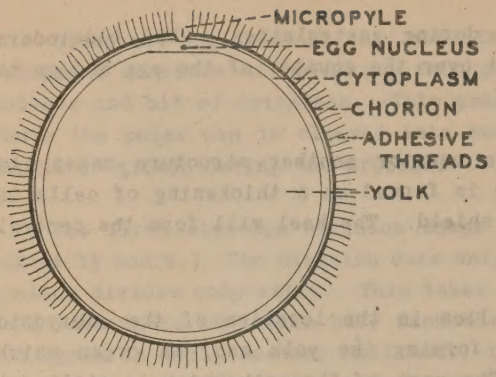
As the keel is being formed and the germ ring passes over the yolk, the primitive endoderm cells continue to expand under the embryonic shield. By 24 hours three definite parts of the primitive endoderm have differentiated. Directly down the center axis of the embryo the chorda has formed, a solid structure which will give rise to the notochord, later replaced by the vertebrae of the backbone. Under the chorda a thin layer of cells forms the secondary endoderm which will form the digestive tract and its derivatives, including the air bladder. To the sides of the chorda, the primitive endoderm becomes the mesoderm, which gives rise to the muscles, skeleton, blood, and all parts of the blood system, kidneys, connective tissue, and part of the skin and reproductive system.

The superficial tissue forms the ectoderm of the embryo, continuous with the part of the blastoderm that forms the yolk sac. The keel is also formed from cells of the deep multicellular layers of the ectoderm as follows: The cells increase in number and form a solid rod of cells, while the rest of the embryonic shield becomes thinner. The cells of the keel become separated from the epidermal layer and continue to grow in depth.

The remainder of the development of an embryo is best described by taking each organ or system in turn and following its development.

FORMATION OF THE CENTRAL NERVOUS SYSTEM AND SENSE ORGANS

The brain and spinal cord of the embryo is represented first by the keel, a solid rod of cells (22 hours). The brain develops from the anterior (front) end of this keel, and by 24 hours enlargements and constrictions have developed which begin to indicate the origin of the primary vesicles of the brain. The spinal cord forms from the posterior (hind) part of the keel.



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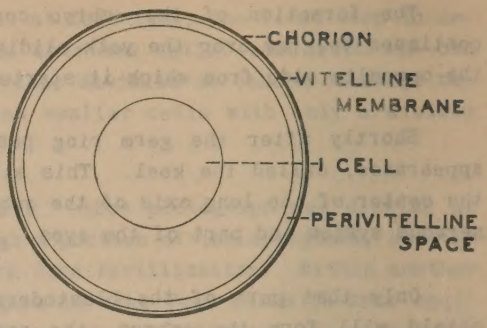

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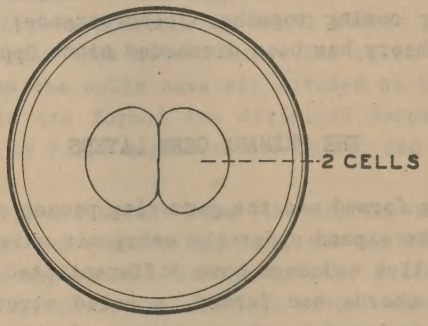

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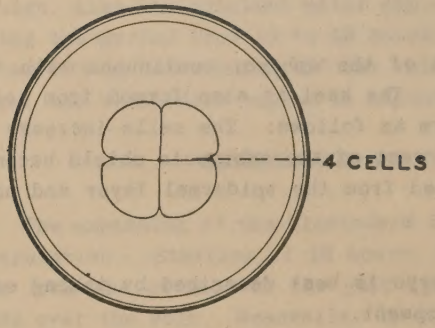

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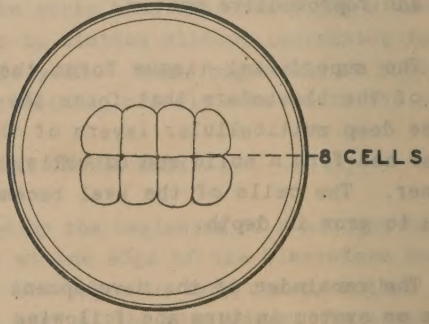

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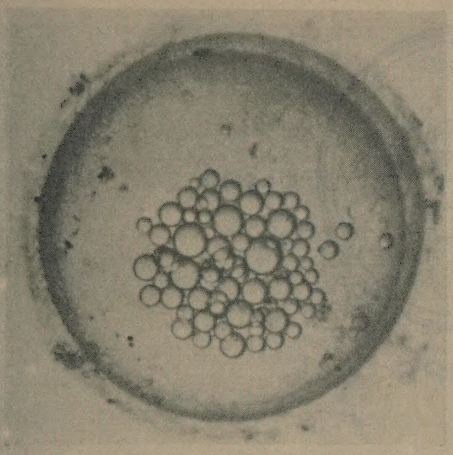
DEVELOPMENT OF A FISH



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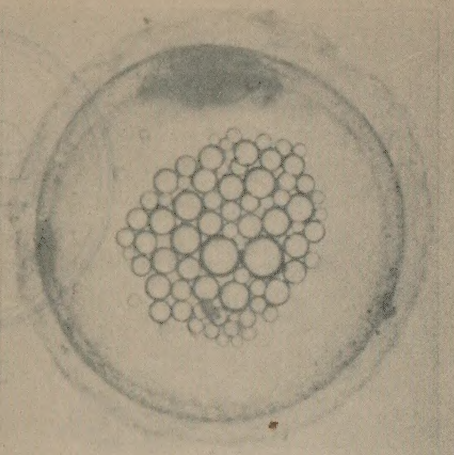

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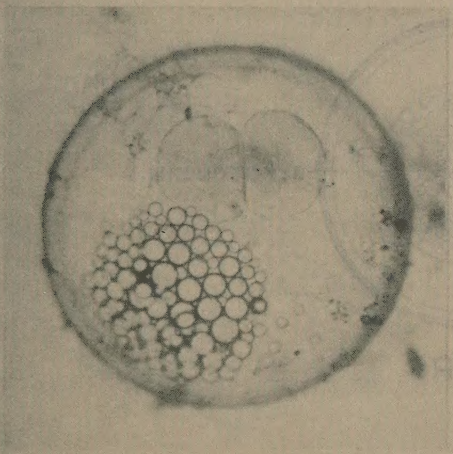

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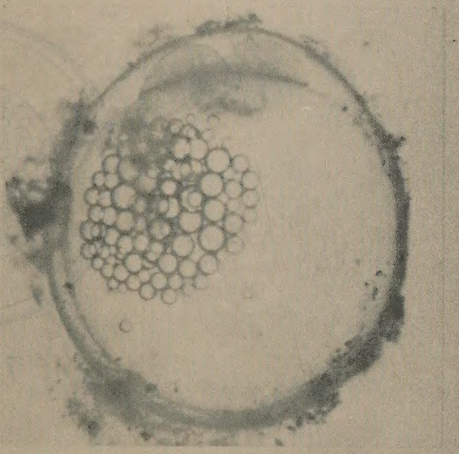

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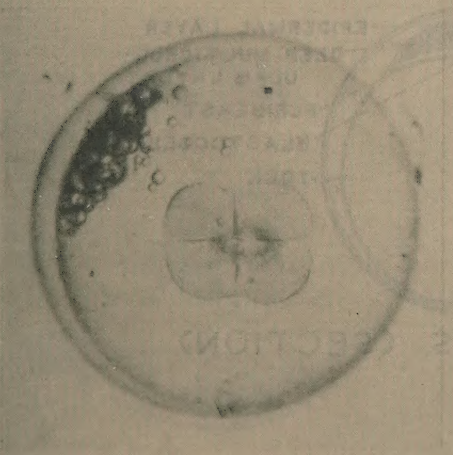

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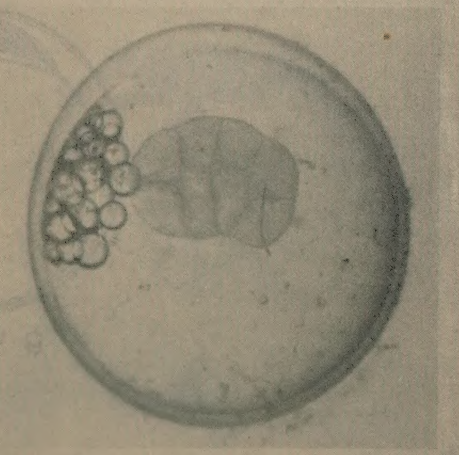

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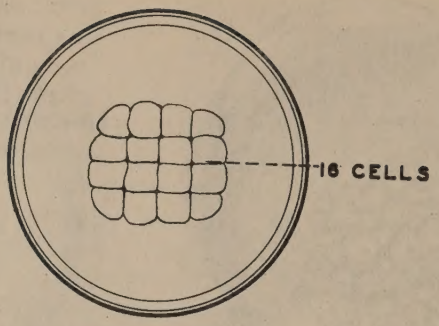

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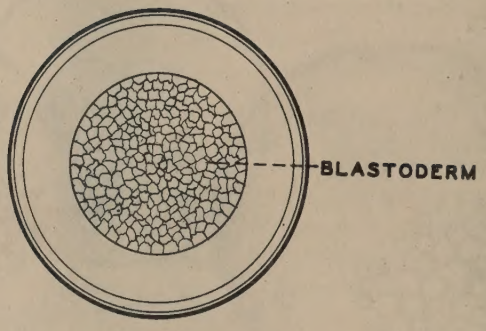

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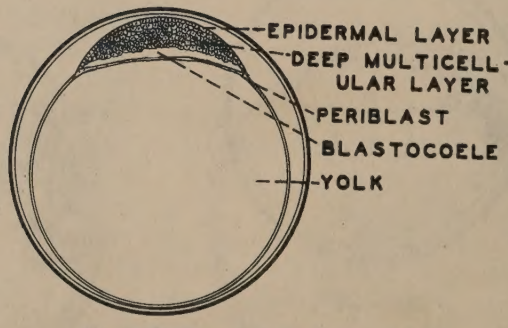

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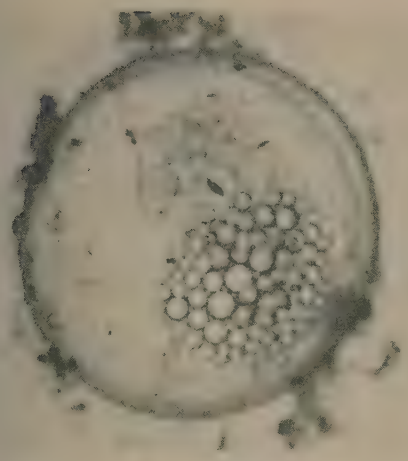

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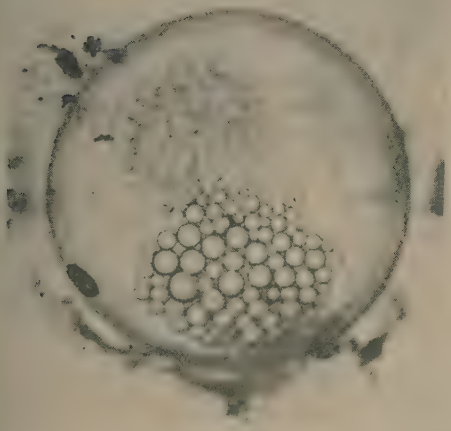

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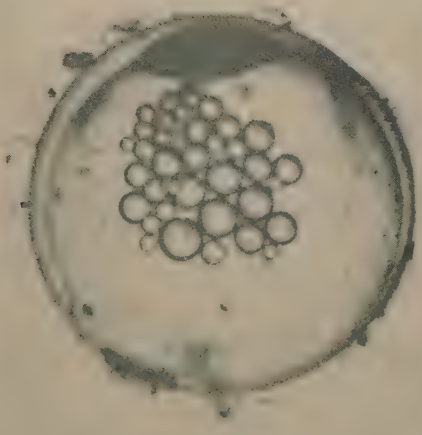

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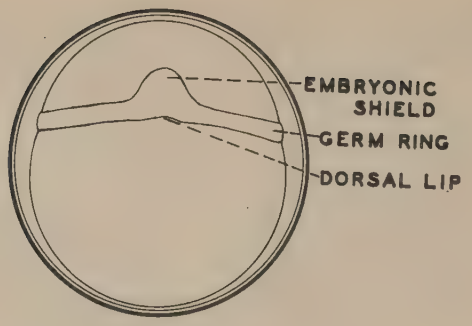

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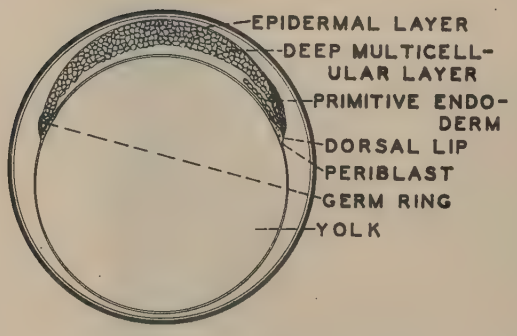

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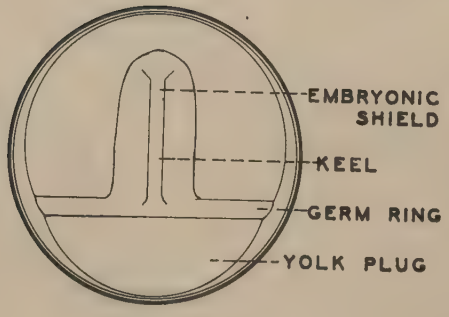

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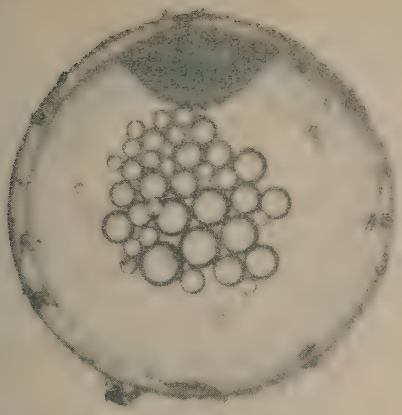

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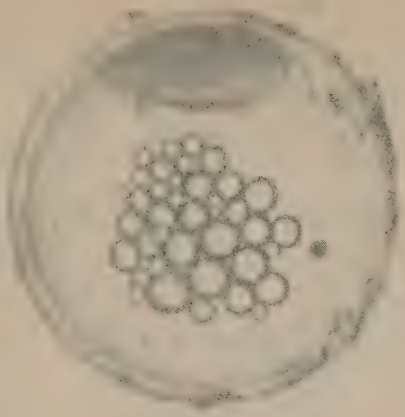

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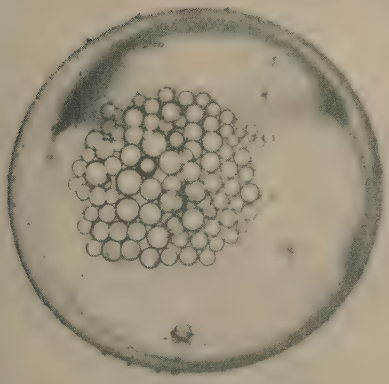

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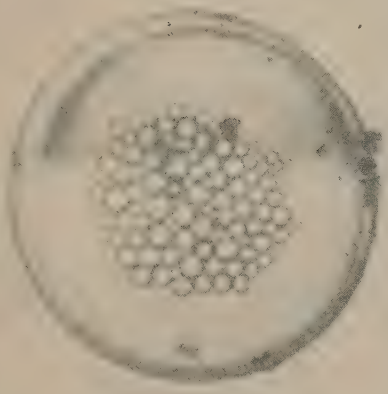

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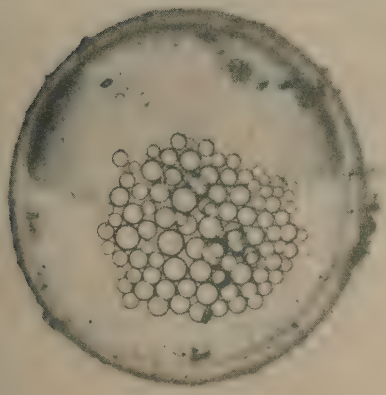

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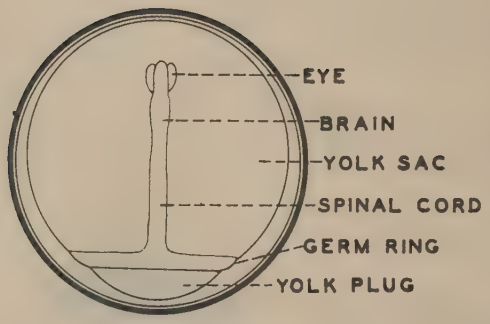

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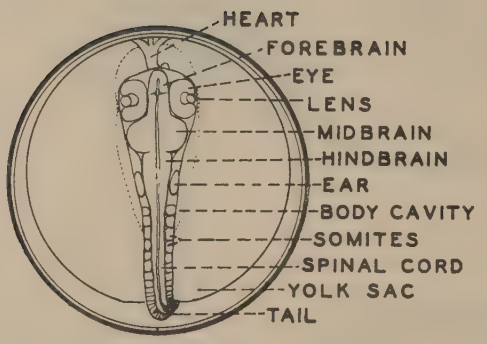

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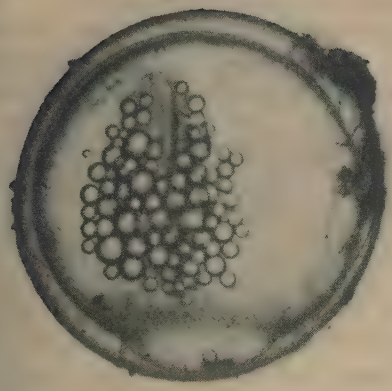

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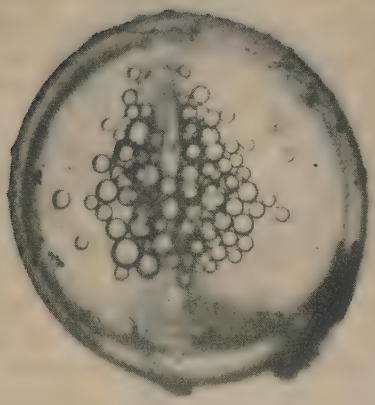

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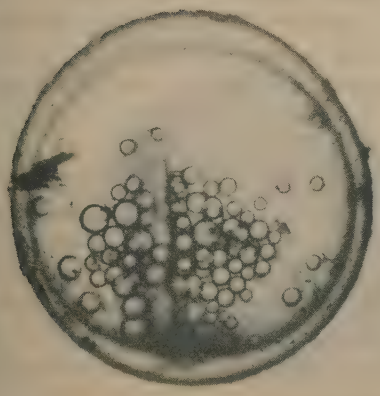

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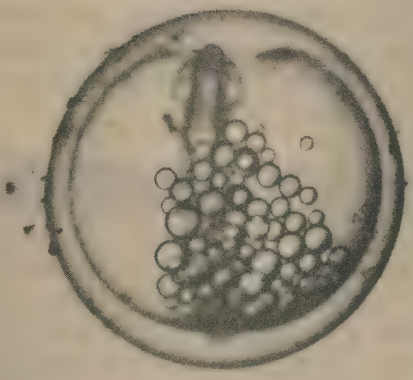


33 HOURS

35 HOURS

42 HOURS

.5342

The eyes form as outgrowths from the region which forms the forebrain. They may be seen at 24 hours and are much larger at 26 hours when the blastopore closes. The spinal cord and brain of adult vertebrates is a hollow tube, and in most vertebrates it first forms as a tube. In the bony fish, on the other hand, the cord forms as a solid rod, as already described, and only later develops a cavity. The origin of the cavity is peculiar. It begins in the eye and may be seen at 33 hours as a slit which extends from each eye across the forebrain. The formation of the cavity of the brain and spinal cord follows soon thereafter and is formed by an extension of the cavity up and down the length of the brain and spinal cord (see 35 hour embryo).

The lens of the eye is first visible at about 34-35 hours. It forms from ectoderm cells of the epidermis in the region where the optic vesicle (eye) first comes in contact with the overlying ectoderm. At the same time that the lens forms the eye becomes cup shaped by the sinking in of the outer cells.

The development of the enlargements and constrictions to form the lobes of the brain is first indicated at 24 hours. The three regions which first develop are called the forebrain, midbrain, and hindbrain. By about 38 hours these three regions become very well marked because the midbrain enlarges rather suddenly at that time, while the forebrain remains small and the hindbrain enlarges only slightly. (See 42 hour drawing.)

Two other sense organs develop in close relation to the brain, namely, the nose and ears. Fish do not hear in the sense that we hear, but they do possess an organ of balance similar to our own. In addition, they have a special type of structure, called the lateral line system because the main sensory part of it lies along lines on the sides of the body of the fish. The ear begins as a thickening in the epidermal ectoderm at about 35 or 36 hours. One portion sinks in to form the organ of balance, while the other part becomes the lateral line. The ear may be easily seen at 40 hours and is very large in later stages (216 hours).

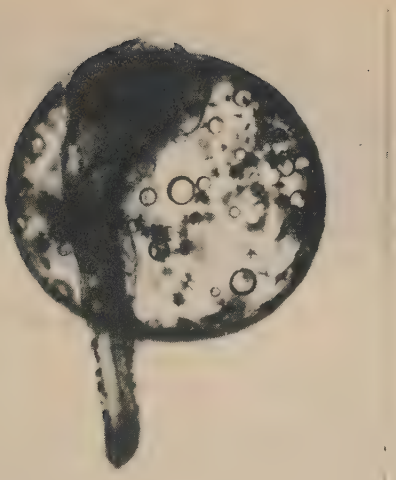
The nose develops as two thickenings of the epidermis in front of the head which later sinks in to form the nasal pits. Their beginning has been observed at about 44 hours.

The spinal cord increases in size and length with the growth of the embryo but undergoes no special changes that may be seen in the living embryos. There is no need of describing the finer details of its development. The spinal cord later becomes enclosed in the vertebrae and the brain is enclosed by the skull, but these changes occur, for the most part, after hatching.

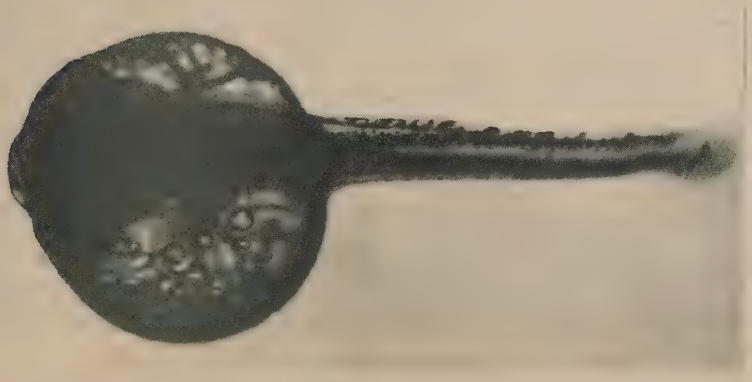
FORMATION OF THE DIGESTIVE SYSTEM

The endoderm forms the digestive system. When first formed, however, it consists of a thin flat sheet of cells lying on the very underside of the embryo. It develops into a tubular structure as follows: The cells lift from the yolk and draw together at the midline, and later the outer (lateral) cells fold under and join to make the tube complete. From the throat cavity (pharynx) outpushings occur to form the gill slits around which the gills later develop.

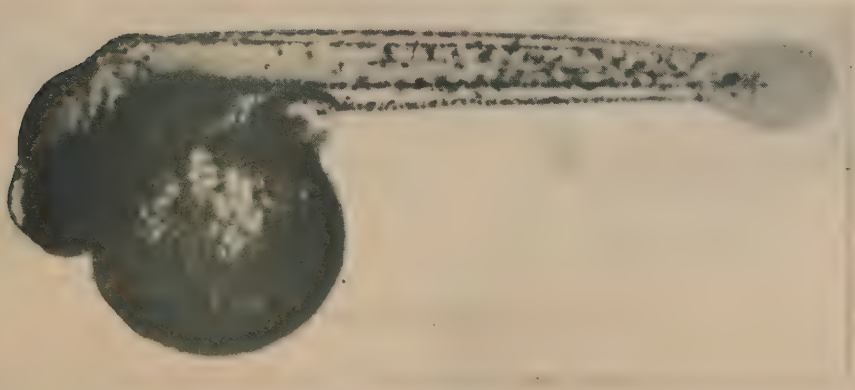
54 HOURS



72 HOURS



114 HOURS



150 HOURS

At the region just behind the heart, the folding of the endoderm to make a tube is not completed but remains open toward the yolk. The liver develops from the tissue in this region and later takes over a large part of the job of absorbing the yolk and supplying the embryo with food.

The air bladder is derived from the endoderm between the liver and the pharynx. I have seen it as early as 78 hours at which time it is still collapsed with no air in it. Its position is indicated in the drawing of a 216 hour embryo.

FORMATION OF MUSCLES AND RELATED STRUCTURES

The mesoderm, when first formed, is a solid sheet of cells lying on either side of the chorda. At about the time the blastopore closes, several important developments begin. First, in the mid-body region, the mesoderm becomes divided into segments called somites. The first one forms in about the middle of the body, and new ones form posterior to it. They form at the rate of about one every half hour to an hour at 77° F. When they are three days old, the embryos have about 35 somites, as many as they ever develop, most of which are located in the tail, of course.

The somites give rise mainly to the muscles and are conspicuous structures at all older stages because of their segmental arrangement. The first somites to form are the first to develop function, and the first movements are seen when the embryo is about 2 days old. Function develops as differentiation progresses posteriorly, and soon after the last somites form, the embryo can move its entire tail.

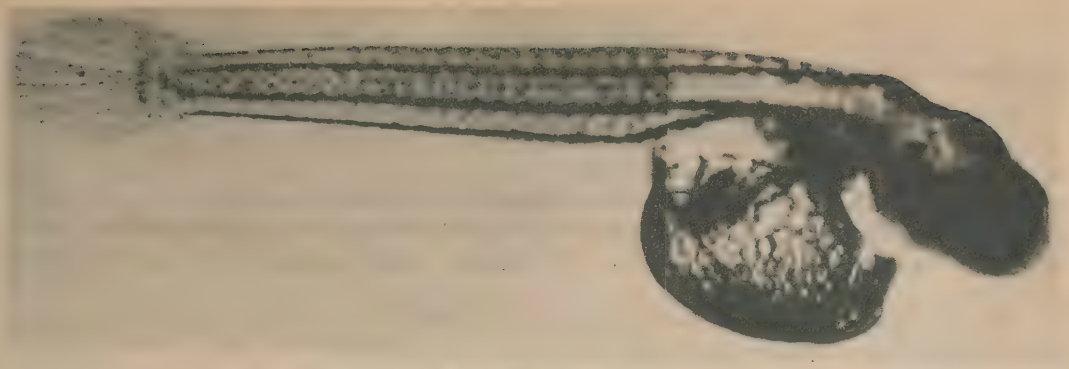
The tail fin and pectoral fins begin to form during the third day. The pectoral fins arise as slight elevations on the surface of the embryo just behind the ears later assuming their fan-shaped appearances. The tail fin is first visible in 4 day embryos and begins to develop its supporting skeleton at 6 days. The pelvic fins develop after hatching.

ORIGIN OF THE TAIL

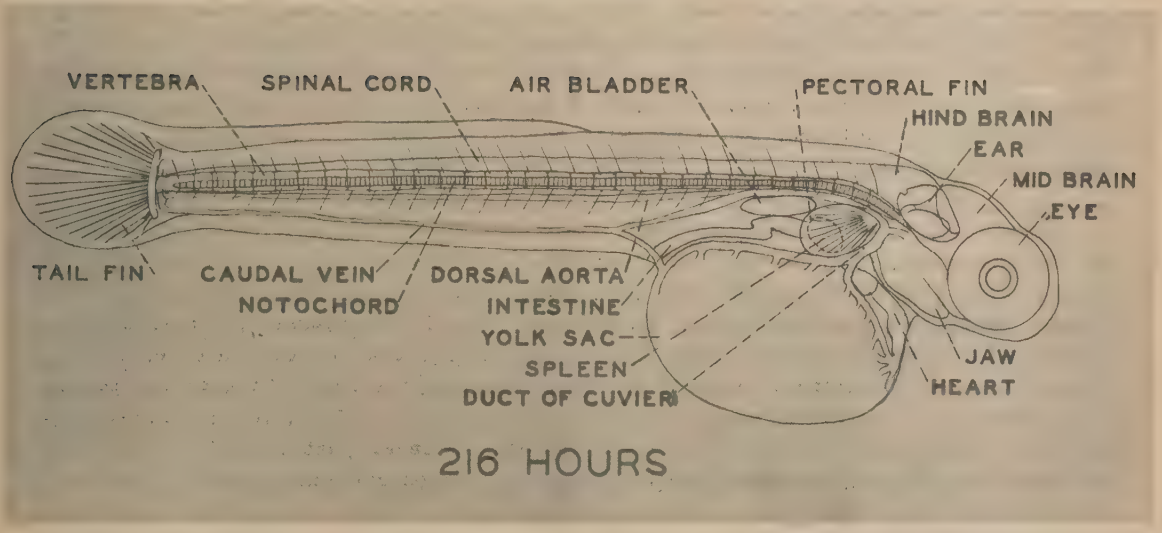
Before proceeding further with the development of internal organs, it may be well to describe the origin of the tail. When the blastopore closes at 26 hours there remains at that spot the posterior end of the keel and the piled up cells of the former germ ring. These structures are located at the site of formation of the tail. The tail begins to form by a differentiation of this mass and soon develops a protuberance which is free from the yolk. Into this protuberance the nerve cord, notochord, and somites grow, increasing in length and differentiating as it progresses. It finally grows to a length of about twice the diameter of the yolk and then ceases forming new somites and develops the tail fin.

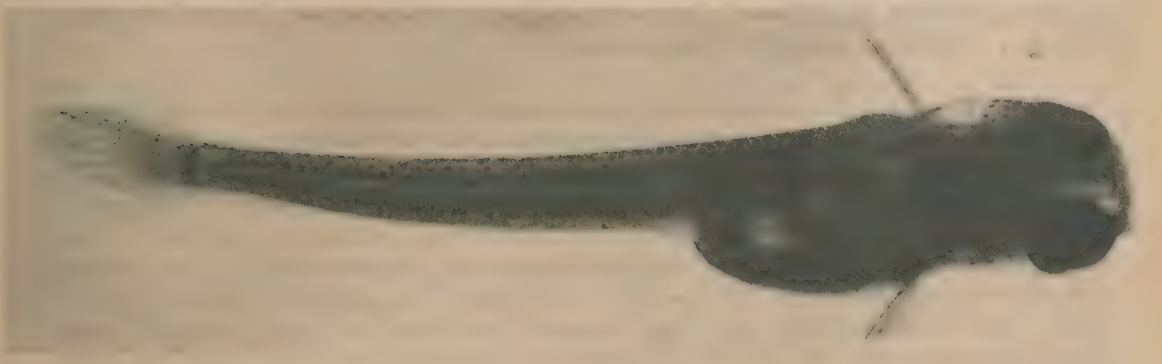
ORIGIN OF THE COELOM AND KIDNEYS

The mesodermal plate which is not involved in the formation of somites gives rise to the coelom and embryonic kidneys. The outer (lateral) region splits into two thin sheets, the upper (dorsal) one of which forms the peritoneum lining the body cavity (coelom), and the inner (ventral) one forms the covering of the internal organs and the mesenteries.



216 HOURS





264 HOURS

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The embryonic kidneys (pronephri) form from the intermediate mesoderm, beginning as a solid rod of cells at about 44 hours. The adult kidney forms after hatching.

DEVELOPMENT OF THE CIRCULATORY SYSTEM

Next to the nervous system, the circulatory system is perhaps the easiest to observe as it develops. It is interesting also because one can watch the development of function, epecially in the heart. This system is also formed from the mesoderm.

Cells called mesenchyme cells, migrate out from the mesoderm of the embryo onto the yolk and there become organized into structures called blood islands. These blood islands form both blood and blood vessels on the surface of the yolk.

At the same time that the blood islands are forming, the heart begins to develop from folds of mesoderm which move down from each side under the pharynx and join to form a tube. This tube can be seen at about 40 hours by viewing the embryo from the side. At about that time, too, it begins to pulsate, but no blood circulates through it because it has not been connected with any blood vessels as yet-- and, in fact, no blood has formed.

Meanwhile, blood vessels also form in the embryo, the first of which is the dorsal aorta forming just beneath the notochord. Continuous with the dorsal aorta is a small vitelline vessel which leads from the junction of the tail with the yolk sac around the yolk to the front end of the embryo. This is the course of the first circulating blood which begins at 46 hours. Within the next 2 hours another set of vessels becomes functional. Some of the blood entering the body of the embryo passes into vessels in the lateral parts of the body called the cardinal veins. The anterposterior cardinals on each side join at about the level just behind the ear and and pass down through a common vessel called the common cardinal or Duct of Cuvier. In the adult these vessels run direcly into the heart. When first formed, however, they pass out over the yolk to connect with the vitelline vessels there and reach the heart in front of the head. Very soon many more vessels appear, and as each organ develops, it also develops its circulation.

The arrangement of the heart and blood vessels is quite peculiar in the fish embryo. Most vertebrates have a special circulation for the yolk sac, but in bony fish all of the blood going to the heart passes through the yolk sac circulation. The heart lies in a peculiar position also. In the adult the heart pumps blood anteriorly, but in the embryo it carries blood from in front of the head to the body. There is no discrepancy in direction if one understands what happens when the heart passes into the body of the embryo. As the yolk is absorbed, the vessels entering the heart come to lie first ventral, and then gradually posterior to their original level. Finally, as the last of the yolk is used up, the Ducts of Cuvier join the sinus venosus of the heart, the vitalline vessels being gradually absorbed as they are no longer needed.

The heart starts as a straight tube and as such begins to pulsate. By the time circulation begins three regions can be made out. Blood enters the sinus venosus where the heart beat originates. That contraction sends the blood into a thin walled auricle continuous with the sinus. The auricle is connected to the more heavily walled ventricle. From the ventricle the blood passes through a short ventral aorta which divides soon after entering the body proper and passes around the pharynx. Above the pharynx they join to form the dorsal aorta. When the gills develop, more arches form from the ventral aorta and carry blood to the gills, as they do also in the adult.

The heart is at first not controlled by nerves, but nervous control develops when the embryos are about 9 days old.

HATCHING

The Fundulus embryo hatches when it is 11 days old if reared at 77° F. At that time its yolk has not all been absorbed, but only a small amount remains. The new hatched embryo is able to swim but not very actively for the first few hours. Its yolk finally is absorbed in a day or more after which it swims very actively and begins to feed.

The mechanism of hatching in Fundulus has been described by Armstrong (1936). Using experimental methods, he was able to show that two factors operate during hatching. The first is the production of an enzyme by glands located in the mouth which soften the chorion. The second factor, and the only one usually observed, is the lashing of the tail which breaks the chorion and frees the young fish.

In preparing the accompanying photographs, the chorion was removed from embryos older than 56 hours so that the mechanism of hatching has not been demonstrated.

REFERENCES

Armstrong, P. B. 1936 Mechanism of Hatching in Fundulus heteroclitus. Biol. Bull. 71, 407.

Newman, H. H. 1907 Spawning behavior and sexual dimorphism in Fundulus heteroclitus and allied fish. Biol. Bull. 12, 314-349.

Oppenheimer, Jane 1938 Processes of localization in developing Fundulus. J. Exp. Zool. 73, no. 3, 405-444.

Wilson, H. V. 1889 The Embryology of the Sea Bass. Bull. U. S. Fish Commission, Vol. IX.

COMPARATIVE FEEDING VALUES OF SOME OF THE MEALS FED TO FISH

By L. R. Donaldson, School of Fisheries, University of Washington
and Fred J. Foster, U. S. Bureau of Fisheries, Seattle, Wash.

USING FINGERLING rainbow trout as test animals, experiments were carried on at the Experimental Hatchery of the University of Washington to compare beef spleen, beef spleen combined with seal meals, commercial salmon meal ("Salmana") and Quilcene salmon meal. Six experimental tanks were used, each tank containing 300 fish at the start of the experiment. The fish in lot No. 1 were fed a diet of 100 percent fresh beef spleen as a control lot. The other five lots, Nos. 2 – 6, were fed diets of 70 percent beef spleen and 30 percent meal. Each lot that received the meals in addition to the beef spleen was fed on a feeding schedule that was based on the amount of beef spleen consumed by the control lot, No. 1. After determining the food consumed by lot No. 1 each of the other five lots was fed total amounts of mixed diets equal to one-half that fed to lot No. 1.

The fish in lots Nos. 2, 3, and 4 were fed diets composed of 70 percent be f spleen and 30 percent seal meal. The seal meals used were prepared by the U. S. Bureau of Fisheries at its plant on the Pribilof Islands. Each of the meals used was prepared by a different manufacturing process. The fish in lot 2 received seal meal "A" that was prepared from fresh seal carcasses, which were cooked, then pressed in an expeller press. Lot No. 3 fish were fed from sealmeal "B" prepared from seal blubber that was cooked, pressed in hydraulic presses, and then put through a grinder to reduce it to a fine textured meal. The fish in lot No. 4 were fed seal meal "H". This meal was prepared from fresh seal carcasses that were cooked, pressed in hydraulic presses, and run through the grinder.

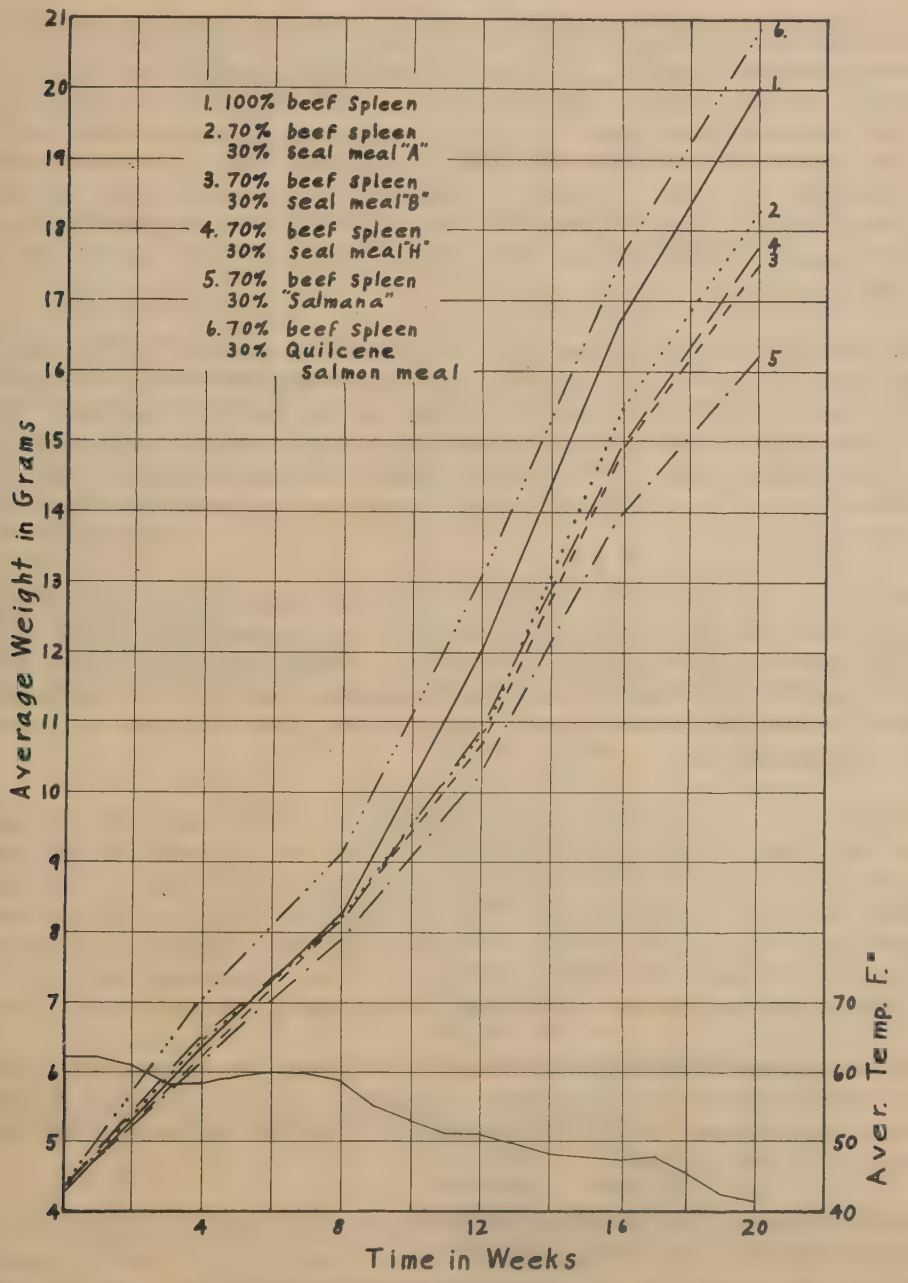
The fish in lot No. 5 received a commercial salmon meal, sold under the trade name "Salmana", as the meal component of their diet. This meal was manufactured in Alaska from the by-products of the salmon canning industry. In processing, the fish waste was presumably cooked, pressed, and then dried.

Quilcene salmon meal was fed as the meal portion of the diet to the fish in lot No. 6. The Quilcene salmon meal was prepared at the Quilcene Station of the U. S. Bureau of Fisheries from the carcasses of spawned-out chum salmon. In processing, the whole carcasses were chopped up, cooked, the fish pulp ground, then dried at low temperatures in an air-tunnel drier. After drying, the dry fish residue was run through a grinder to reduce the size of the particles to a fine textured meal.

In preparing the mixed diets for feeding, the beef spleen was ground through the fine plate of a power grinder, then the meals mixed thoroughly with the meat component of the diet. The mixtures were stored in the ice box several hours before feeding to allow the meat juices to be absorbed by the meals. No water was added to the mixed diets either in preparing them or during the feeding process.

Discussion

The feeding tests were carried on for 20 weeks and the results are summarized in Table I. The growth curves as indicated by averages of sample weights determined at four week intervals are presented in the accompnying figure.



Comparative increase in weight of rainbow trout fingerlings fed diets of beef spleen or beef spleen combined with meals.

The control lot, No. 1, fed a diet of beef spleen, increased from an initial average weight of 4.27 grams to 20.01 grams average weight in the 20 weeks. This was an increase of 369% in weight. The fish in this lot consumed 21,600 grams of food. For each pound of food fed 0.21 of a pound of fish was produced or 4.76 pounds of food were used in producing one pound of fish. Using $0.04 a pound as the cost of the beef spleen, the fish in this lot were produced at a cost of $0.19 a pound.

The three lots of fish fed beef spleen combined with seal meals (Nos. 2, 3 & 4) gave almost identical results. The rate of growth was slightly inferior to that of the control lot fed a diet of 100% beef spleen. Each lot received one-half as much total food as was fed the control lot or 10,800 grams of the mixed diets was fed each lot during the 20 weeks the experiment was in progress. The utilization of food was higher, however, for 2.70, 2.78 and 2.70 pounds of food, respectively were required to produce a pound of fish in each lot. At a cost of $0.01 a pound for seal meal and $0.04 a pound for beef spleen, the costs per pound of fish were $0.084, $0.086 and $0.084.

The mortality in lot No.2 was 17 fish or 5.7%, the same as that in the control lot. The mortality for lot No. 3 was 7 fish or 2.3% while the fish in lot No. 4 experienced a mortality of 4 fish or 1.3% during the 20 weeks feeding test. The fish that died in lot No. 2 were small fish that died during the early stages of the experiment. The meal fed to this lot was not as fine in texture as that of the meals fed to the other lots. These large particles of meal may have been the cause for much of this early mortality.

The fish in lot No. 5, fed a diet of 30% commercial salmon meal and 70% beef spleen, produced the least growth of any of the lots, increasing only 279% in weight. In food utilization this lot was also the lowest of any of the mixed diets, with 3.13 pounds of the mixed food required to produce a pound of trout. At a cost of $0.035 a pound for the meal and $0.04 a pound for the spleen used, the cost of producing a pound of fish was $0.121.

The fish receiving Quilcene salmon meal mixed with beef spleen (No. 6) grew the most rapidly of any of the experimental lots. On one-half as much food by weight as was fed the control lot, the fish in this lot increased 389% in weight. The best food utilization was also obtained in this lot with 0.45 of a pound of fish produced by each pound of the mixed diet fed, or 2.22 pounds of food required for each pound of fish produced. Using $0.04 a pound as the cost of the salmon meal and $0.04 a pound as the cost of the beef spleen, each pound of fish was produced at a cost of $0.089.

From the preceding experiments it might be concluded, in general, that diets of 70% beef spleen and 30% meals produced satisfactory growth of rainbow fingerlings when fed in amounts equal to one-half the weight of food fed the control lot that received a diet of beef spleen.

The differences in efficiency of the meals used would make it necessary to introduce a small correction in the amounts of food fed each lot to obtain the same rate of growth as the control lot. By reducing the amount of food fed to the lot that received Quilcene salmon meal to less than one-half the weight fed to the control lot, and increasing slightly the amounts fed to the groups receiving seal meal and the commercial salmon meal, the growth rates might be further equalized.

TABLE I. SUMMARY OF EXPERIMENTAL FEEDING TESTS

WITH RAINBOW TROUT FINGERLINGS, AT THE EXPERIMENTAL HATCHERY
UNIVERSITY OF WASHINGTON

Date experiment started: September 1, 1936, Concluded: January 18, 1937 (20 weeks)

Initial number of fish per tank: 300

Average water temperature: 53°F.

	Lot number					
	1	2	3	4	5	6
Initial length av cms.	6.45	6.45	6.45	6.45	6.45	6.45
Final length av. cms.	10.97	10.81	10.84	10.98	10.41	11.56
Percent gain in length	70	68	68	70	61	79
Initial av. wt. grams	4.27	4.31	4.29	4.27	4.28	4.27
Final av. wt. grams	20.01	18.25	17.51	17.77	16.21	20.86
Percent gain in wt.	369	323	308	316	279	389
Condition factor	1.50	1.45	1.39	1.34	1.44	1.36
Mortality number	17	17	7	4	12	4
Percent mortality	5.7	5.7	2.3	1.3	4.0	1.3
Total food in grams	21,600	10,800	10,800	10,800	10,800	10,800
Efficiency factor	.21	.37	.36	.37	.32	.45
Lbs. of food per lb. of fish	4.76	2.70	2.78	2.70	3.13	2.22
Cost per lb. of fish	.19	.084	.086	.084	.121	.089

Diets: Lot No. 1. 100% beef spleen
" " 2. 70% beef spleen
30% seal meal "A"
" " 3 70% beef spleen
30% seal meal "B"
" " 4 70% beef spleen
30 seal meal "H"
" " 5. 70% beef spleen
30% "Salmana"
" " 6. 70% beef spleen
30% Quilcene salmon meal

Cost of various foods used: Beef spleen $0.04
Seal meal 0.01
"Salmana" 0.035
Quilcene salmon meal 0.04

EFFECT OF FERTILIZERS ON PLANKTON PRODUCTION AND ON FISH GROWTH IN A WISCONSIN LAKE

By C. Juday and C. L. Schloemer, University of Wisconsin
and Clarence Livingston, Works Progress Administration

INTRODUCTION

IN 1931 a small lake situated about five miles from the Trout Lake Limnological Laboratory in northeastern Wisconsin was selected for a series of experiments on the effect of fertilizers on plankton production and on fish growth. This body of water is known locally as Weber Lake; it has an area of 38.5 acres, a maximum depth of 44 feet and a volume of 1,482,000 cubic yards. The experiments have been carried on through the cooperation of the U. S. Bureau of Fisheries, the Wisconsin Conservation Department and the Wisconsin Geological and Natural History Survey; the Works Progres Administration has cooperated in the fish growth part of the program.

WEBER LAKE

Weber Lake belongs to the landlocked or seepage type; that is, it has neither an inlet nor an outlet, so that all outward movement of the water, except for evaporation takes place by seepage through the surrounding glacial deposits. The water is very soft; the original calcium content was 0.7 part per million and magnesium 0.5 part per million.

As a basis for judging the effect of the fertilizers on the growth of the microscopic life of the lake, series of quantitative observations were made each week on the standing crop of plankton during the months of July and August, 1931. To these data were added seven series of observations which were made during these months between 1925 and 1929. As a standard for comparison of fish growth, more than a thousand specimens of yellow perch were taken between 1928 and 1932 for age and growth studies. Only two species of fish are found in the lake, namely yellow perch and small mouthed black bass; it was necessary to depend chiefly upon the former for the growth studies because it was found inadvisable to remove enough small mouths each year to give a good growth curve for that species.

FERTILIZERS

So far six different fertilizers have been emplcyed. They are superphosphate (1750 pounds), lime (3300 pounds), ammonium sulphate (900 pounds), muriate of potash (1250 pounds), cyanamid (1200 pounds) and soybean meal (3000 pounds). Phosphate alone was added in 1932, phosphate and lime in 1933, phosphate, lime and ammonium sulphate in 1934, muriate of potash and cyanamid in 1935 and soybean meal in 1936.

The superphosphate was placed in boxes that were attached to two buoys anchored in different parts of the lake; the boxes had holes bored in them so that the water currents could pass through them and carry away the dissolved phosphate and distribute it over the lake. In this way the phosphate content of the water was increased more than fivefold. The other fertilizers were distributed in the shallow water near shore where the depth was about two feet. The lake is deep enough to be thermally-sratified in summer, so that any fertilizer that sank into the lower stratum would not be available for the phytoplankton until the autumnal overturn and circulation of the water.

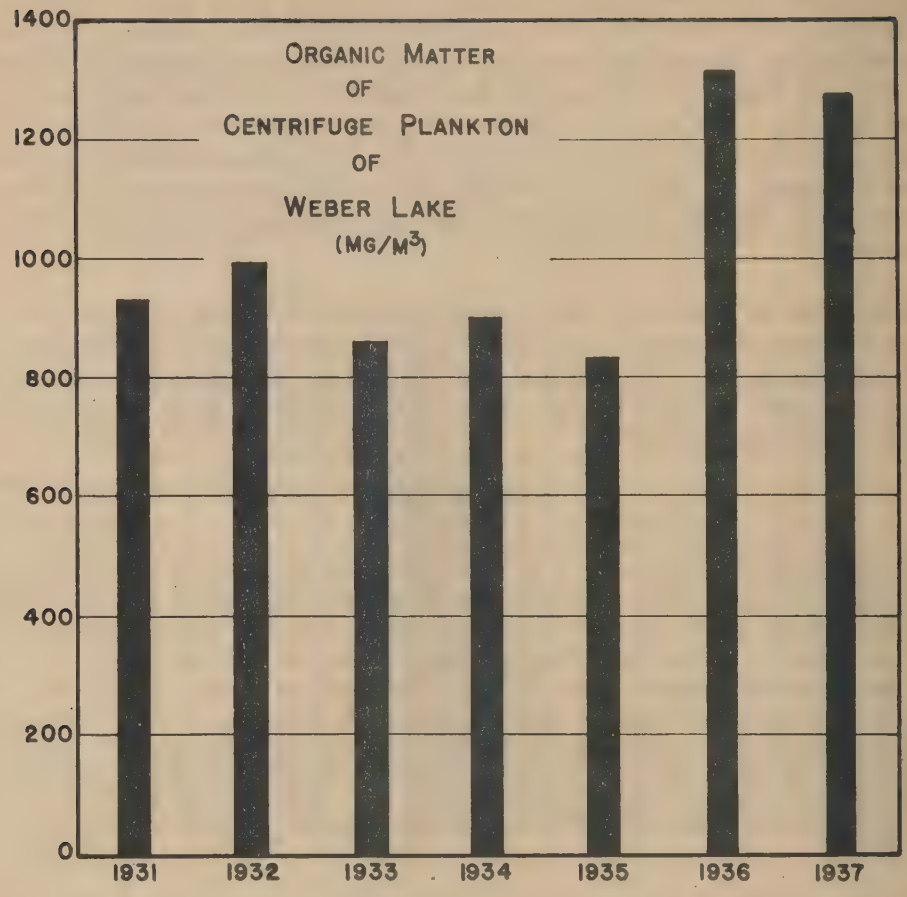
The addition of the lime brought the calcium content of the water up to a little more than 1.5 parts per million, but the magnesium was substantially the same as before the lime was added. The nitrates were doubled by the addition of ammonium sulphate and cyanamid; in 1936 however, the amount was substantially the same as before these two fertilizers were added.

PLANKTON CROP

The accompanying figure shows the average standing crop of plankton from 1931 to 1937, inclusive, in terms of milligrams of dry organic matter per cubic meter of water. The diagram shows that the average for 1932, when the first superphosphate was added, was somewhat larger than that of 1931; it was 931 milligrams per cubic meter in 1931 and 996 milligrams in 1932. This is a difference of only 7% and falls within the limits of annual variations. The average plankton crops in 1933, 1934 and 1935 were below that of 1931, with 1935 as the smallest of the three years. When soybean meal was added in 1936, the average standing crop of plankton rose to 1311 milligrams per cubic meter of water; this was 40% larger than the crop in 1931 and 57% above that of 1935.

It seems reasonable to conclude that the marked increase in 1936 was due mainly if not wholly to the soybean meal fertilizer. It is possible that the fertilizers added before 1936 played some part in increasing the plankton production when the soybean meal was used, but this is doubtful because the phosphate, nitrate and potash content of the water had declined to pre-fertilizer level by that time. The calcium content, however, was still above the 1931 level, or 1.2 parts per million in 1936 as compared with 0.7 part in 1931.

No fertilizer was added in 1937 in order to determine whether the soybean meal might be effective for more than one year. It was found that the dry organic matter of the standing crop of plankton in 1937 was only 3% below the 1936 crop, which seems to indicate that the meal had an important effect upon the plankton crop in 1937. According to the present plan no fertilizer will be added in 1938 in order to determine whether the average standing crop of plankton will still be above the average previous to 1936.



Average quantity of dry organic matter in standing crop of plankton in Weber Lake during the summers from 1931 to 1937 inclusive. The quantities are indicated in millimeters per cubic meter of water.

FISH GROWTH

Since the rate of growth of fish in a lake varies from year to year, or during a cycle of years, this criterion must be used cautiously in assessing the effect of fertilizers. Perhaps the best way to avoid this difficulty is to determine the average rate of growth during the period included in the experiments (1931 to 1936, inclusive) and then compute the deviation from this average for the different years. The year 1937 can not be included in the results because the specimens of yellow perch collected in May 1938 had not formed a winter ring at the time of their capture.

The rate of growth of the yellow perch of Weber Lake in 1931 and 1932 was 5% and 7.5% respectively below the normal rate for 1931-1936. During the next three years (1933, 1934 and 1935) it was from 1% to 3% above normal. In 1936 however, it was 16% above normal, which seems to indicate that there was an appreciable increase in the perch growth rate correlated with the increased plankton production in that year. It will require the 1937 material to positively confirm this point.

A more definite correlation between plankton production and growth rate was found in the small mouthed black bass of Weber Lake. On August 3, 1937, 110 specimens of this species of fish were taken; all of them were in the second year of life since their scales showed only one annulus. That is, they belonged to the 1936 year class. They ranged from 4.6 to 9.1 inches in total length, with an average of 6.37 inches for the 110 specimens. It seems probable, therefore, that the larger specimens in this group would have reached a length of 10 inches before the end of the second growing season. The calculated lengths of 41 specimens obtained in previous years showed that they did not reach this length until the middle of the third growing season or later. Thus some of the 1936 year class were able to reach a length of 10 inches almost a year earlier than the average in previous years. The average total length at the end of the first year of life in the 41 specimens obtained between 1927 and 1931 was 3.15 inches, while that of the 110 specimens taken on August 3, 1937, was 4.44 inches; that is, the average growth of the small mouths hatched in 1936, when the plankton crop was about 40% larger than in previous years, was 1.29 inches greater in he first year of life than that of the 1927-1931 period. It seems safe to conclude, therefore, that increased rate of growth of the small mouths in 1936 was correlated with the larger plankton crop of that year and that the latter in turn was correlated with the soybean meal fertilizer.

COST OF FERTILIZERS

One of the problems involved in the experiments was to obtain appreciable results with as small a quantity of fertilizer as possible so that the cost of treating lakes would not be prohibitive. In the various experiments the cost of the fertilizer ranged from 50 cents per acre in 1931 to $1.10 per acre for the soybean meal in 1936. Since the soybean meal added in 1936 seems to have been effective in producing a large crop of plankton again in 1937, the cost of this fertilizer may be regarded as only 55 cents per acre for each of these years.

The fact that the soybean meal gave best results probably indicates that the organic content of the meal was more effective than the inorganic fertilizers used singly or in groups so far as Weber Lake is concerned. While the phosphate, nitrate and potash content of the water is very small, it looks as if the organic content is the limiting factor in the plankton production. The dissolved organic matter ranges from 3.5 to 5.5 milligrams per liter of water, which is very much smaller than the qauantity found in plankton-rich lakes. Further experiments, however, will be required to answer this question definitely.

TROUT PRODUCTION IN FISH LAKE, UMPQUA NATIONAL FOREST - 1937

By P. R. Needham, U. S. Bureau of Fisheries and E. P. Cliff, U. S. Forest Service

MANY LAKES in the West have been tritely christened Fish Lake; a name which suggests full creels. Occasionally, one of these lakes lives up to its name. Such a one is the famous Fish Lake of the Fishlake National Forest in central Utah. Another is located in the headwaters of the South Umpqua River in the Umpqua National Forest in southwestern Oregon, and is the one we are concerned with here. This ninety-acre mountain jewel nestled between heavily timbered ridges of the rugged Cascade Mountains has long had an enviable reputation as a fish producer. For many years hardy fishermen have hiked over the Umpqua-Rogue River Divide from the famous Rogue Valley to partake of the bounties of Fish Lake. Many stories are told of fabulous catches and the sacks full of rainbows that were toted back over the mountain. In recent years the construction of a road up the South Umpqua River, from Tiller, Oregon, to within six miles of the lake has made it more accessible to anglers. The excessive catches have been eliminated by rigid enforcement of bag limits but the lake still lives true to its name. It holds a piscatorial treat for all who are willing to climb six stiff miles of trail to reach it.

A forest guard is stationed at this lake during the summer months for the primary purpose of protecting the surrounding forested areas from fire. The guard station is strategically located at the only improved forest camp on the lake which enables the guard to easily contact all fishermen. Several boats and rafts have been placed on the lake by the Forest Service for the use of fishermen. These are returned to a landing near the camp, which further improves the guard's opportunities to contact anglers.

The writers visited Fish Lake during the summer of 1936 and were immediately convinced that the set up offered an excellent opportunity to obtain accurate information on the total production of trout, annual yield per acre of surface area, catch per unit of fishing effort, and other pertinent data that would be valuable in preparing a practical, sound management plan for the lake. It was also felt that the data obtained would be useful in evaluating the productivity of similar lakes in the Cascades Consequently, plans were made for taking detailed catch records.

CREEL CENSUS METHOD

During the 1937 fishing season creel census data was obtained by the forest guard under the direct supervision of the district ranger and the forest supervisor. Each angler was personally contacted by the forest guard before going onto the lake. The guard met him again at the camp when he returned with his catch, obtained his name and

address, and recorded by species the number of fish caught. Each fish was measured and weighed on a pair of spring scales. The total and average weight and average length of the catch, and the length and weight of the largest fish in each catch were recorded. Total hours fished was likewise recorded for each angler for each day's fishing on the lake. In all cases, the fish were measured from the tip of the snout to the tip of the tail, or "fisherman's" length. All were recorded to the nearest one-half inch. Additional information on the method of angling, type of lures used, weather conditions, time of day when fish were caught, and condition of the fish were noted on a form specially prepared for the purpose.

The first catch records were obtained on May 8, 1937. Every trout that was caught in Fish Lake from that time until October 1, 1937, when the guard station was closed for the season, was recorded. The forest guard was absent from his station on fire duty on one occasion and during that time a cooperator took over the responsibility of keeping the records. There was no fishing on the lake prior to May 8. It is estimated that only 10 anglers visited Fish Lake after October 1 and that they caught a total of 150 fish.

Excellent cooperation was received from the anglers. Most of them evidenced much interest in the records and asked many questions concerning their purpose. They were particularly interested in knowing how many fish had been caught, the size of the largest fish, and the name of the man who had taken it. Many of them liked to compare their catches with those taken by other anglers. Every effort was made to keep the interviews with fishermen on a friendly and cooperative basis. The forest guard was admirably suited for this type of work. He was well acquainted with fishing conditions in the lake and was able to give the fishermen much of the advice they sought on the most likely places to fish, the best time of day, what particular bait or lure to use, and to answer many of the thousand and one questions which fishermen are prone to ask. Through these friendly and intimate contacts, the forest guard made many friends, both for himself and for the cause of conservation as was evidenced by the numerous verbal and written acknowledgements of appreciation for the treatment received at Fish Lake.

In 1937 the Forest Service in cooperation with the U. S. Bureau of Fisheries made a survey of all of the streams and lakes in the South Umpqua watershed within the national forest.

Emphasis was placed on studies relating to the physical and biological factors upon which it would be possible to erect suitable stocking policies. No study of chemical conditions was made because it seemed unnecessary by reason of the fact that there is no pollution problem in the waters surveyed and all of them apparently are well aerated, being clear, cold mountain waters.

Rather intensive observations were made on Fish Lake in a special effort to obtain accurate information on environmental conditions so that the data could be correlated with and interpreted in terms of fish production as determined from the catch records. A few of the observations from this work that are pertinent to the present discussion will be found below.

ACKNOWLEDGEMENTS

The writers wish to acknowledge the excellent work of individuals responsible for collecting the data which makes this report possible, and for the valuable assistance of persons who in other ways aided in carrying out this program. Special credit is due to A. R. Roth who conducted the survey of the streams and lakes of the South Umpqua drainage, and from whose report (1937) the writers have freely drawn material for this paper; to Forest Guard Earl Duncan who collected the catch records, and to Forest Supervisor V. V. Harpham and District Ranger Avery Berry, in charge of the Umpqua National Forest and South Umpqua Ranger District respectively, without whose wholehearted support and assistance the projects could not have been carried on.

PHYSICAL FEATURES OF FISH LAKE*

As previously stated, Fish Lake has an area of approximately ninety acres. The maximum depth as reported by Roth (1937) is 141 ft. with the greater portion of the bottom area running between fifty and one hundred feet in depth. (See Map.) The bottom is composed mostly of fine silt and mud with a small percentage of gravel, in areas less than twenty feet deep. Deeper areas consist largely of silt and detritus. The shore line of the lake is heavily wooded for the most part. A smaller portion of its margin is wet or boggy, and, less still, rocky.

Five main tributaries, the largest being High Rock Creek, contribute a small total flow into the Lake. All fluctuate considerably and all are spring-fed, but at low water stages several of them sink into the gravel and dry up before entering the Lake.

Excellent spawning conditions are found in three cold tributaries of Fish Lake. During one day, at the height of the 1937 spawning season, 1000 rainbows were counted in Box, Duncan, and High Rock Creeks. However, much of the effectiveness of High Rock Creek, the largest tributary, is lost as the water sinks into the gravel in midsummer leaving the spawn stranded along about one-quarter mile of the stream bed. There appears to be little possibility of remedying this situation through stream improvement. Some stream improvement work which bettered spawning conditions was carried out in 1937 on Box and Duncan Creeks. Further improvements such as straightening the channels and the addition of riffle bars might aid spawning on all three creeks. With these improvements further stocking of Fish Lake might not be necessary as natural spawning might supply more than enough fish to replace those caught from the Lake each year by anglers.

Turbidity as measured with a Secchi disk ranged between three and eighteen feet, depending upon amounts of plankton algae and wind disturbance.

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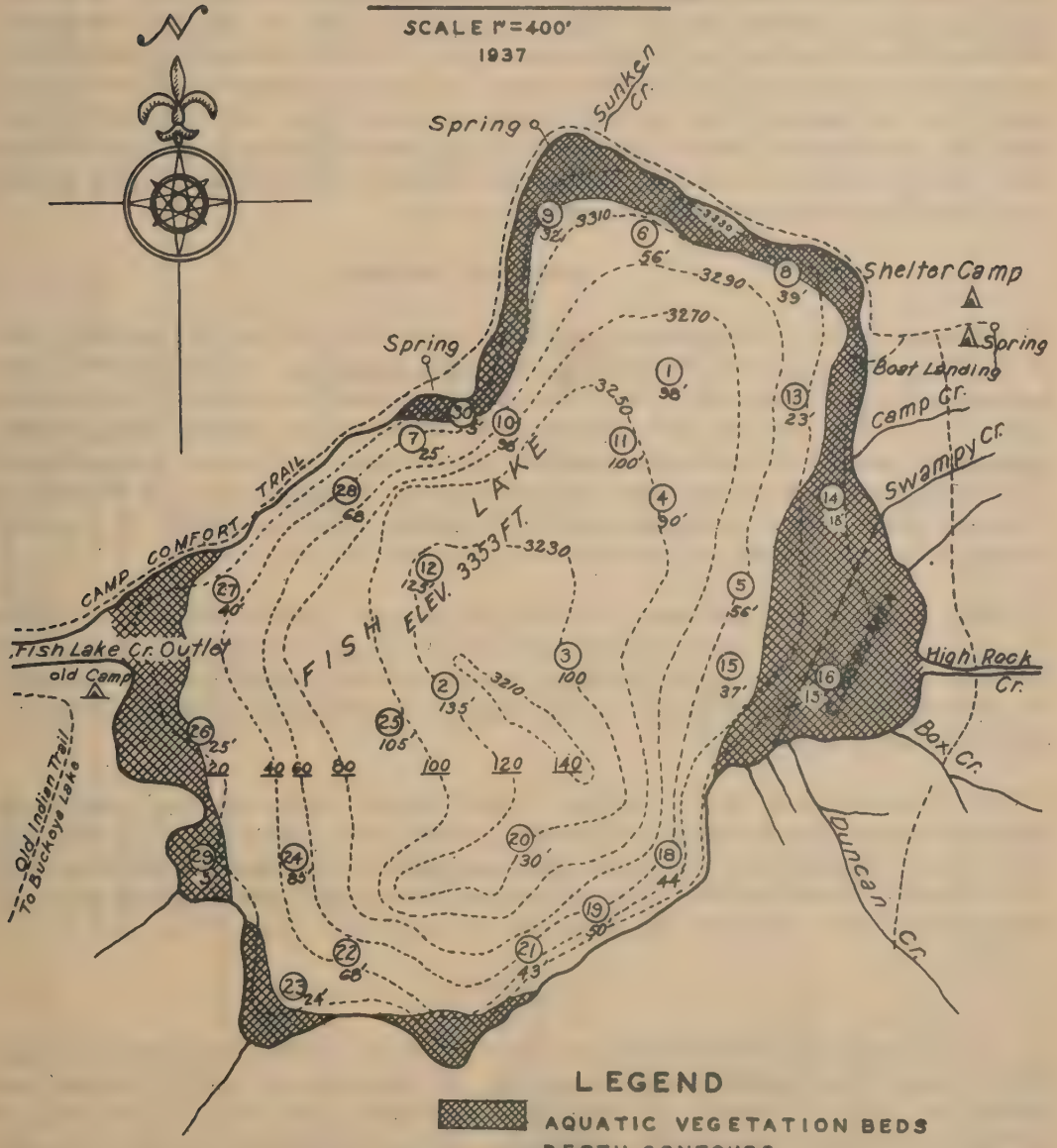
*Most of the following data on physical and biological features of Fish Lake are based on Mr. A. R. Roth's survey made in 1937 (Roth, 1937).

MAP OF FISH LAKE
UMPQUA NATIONAL FOREST
DOUGLAS COUNTY, OREGON
T. 29S. R. 3E. SEC. 5&6

SCALE 1"=400'
1937



LEGEND

- AQUATIC VEGETATION BEDS
- DEPTH CONTOURS
- TRAILS
- ⊙ BOTTOM SAMPLE STATIONS
- 35 FIGURES INDICATE DEPTH FROM SURFACE

Water temperatures in Fish Lake on July 10, 1937, with clear weather were as follows: Inlets 48°F., cutlet 66°F., and surface 66°F. Air temperature on this date was 62°F.

Thermal stratification of the Fish Lake waters is quite evident. Surface waters were warmed up as high as 75°F. by the sun's rays during short periods of the day. Water temperatures decreased gradually with increased depth to a minimum of 40°F. between 60-foot and 140-foot depths. Good growing temperatures for trout, in the summer at least, would therefore be found approximately at depths between 10 and 40 feet. Observations of fishermen confirm these data. In the spring when the water is cooler many trout are taken on flies and by trolling at the surface. However, as the water warms up, trout seek the cooler, deeper layers and deeper fishing is required to catch them. In future work it would be desirable to determine the amounts of oxygen present at various depths to supplement the temperature data.

BIOLOGICAL FEATURES

Emergent plants are numerous along some parts of the shores of Fish Lake. One of the most abundant is the horse-tail, Equisetum talmateia. The yellow waterlily, Nymphaea advenţa is found only over a few scattered areas in the lake.* In the shoal areas of Fish Lake may be found luxuriant beds of submerged plants. The pondweed, Potamogeton lucens, and coontails, Ceratophyllum demersum, grow in such vast quantities as to hide the bottom of the lake. An aquatic moss, Fontinalis sp., is abundant in shallower depts. Algae, Spirogyra, sp., and Vaucheria, sp., may be found in abundance in the shoal areas as well as in waters to a depth of 50 feet.

Fish Foods.— The food supply of Fish Lake is rich. This is borne out both from the quantitative bottom foods studies given below, as well as by the 5946 well-conditioned trout that were caught by anglers in the Lake in the 1937 season. The abundant aquatic vegetation and bottom of rich organic detritus harbors a host of aquatic foods both large and small.

Of shore-dwelling foods, crayfish, water beetles, water striders, caddicefly larvae and pupae, and the nymphs of mayflies, dragon flies, and damselflies were common. Scuds ("shrimp") of two species, Hyalella azteca and Eucrangonyx gracilis, were also abundant. Plankton hauls from open waters of the Lake likewise showed an abundance of waterfleas, copepods, and ostracods; all good fish foods.

Bottom Foods

Thirty quantitative bottom samples were taken in Fish Lake using an Ekman dredge. These samples yielded 2470 animal organisms, or an average of 329.2 organisms per square foot of bottom area. Of these, over 83 percent were taken in areas over 25 feet deep. Phantom midge larvae, Chaoborus, formed the greater portion of the organisms found, with other midge larvae and pupae, bristleworms, scuds, snails, and clams, and alder-fly larvae following in the order named. The average number of organisms per Ekman sample was 82.3 (Table 1). These data show that Fish Lake is exceedingly rich in available food organisms. Table 1 summarizes the quantity and kinds of bottom foods found in Fish Lake.

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*Determinations of aquatic plants from Roth (1937) by Dr. M. E. Peck of Williamette University, Oregon.

Table 1

Numbers and kinds of bottom foods found in Fish Lake, 1937*
(From Roth, 1937)

Food Organisms	No. Organisms per ¼ sq. ft. from bottoms less than 25 ft. deep (9 samples)		No. Organisms per ¼ sq. ft. from bottoms over 25 ft. deep (21 samples)		No. Organisms per ¼ sq. ft. for lake as a whole (30 samples)	
	Total No.	Av. No. per Sample	Total No.	Av. No. per Sample	Total No.	Av. No. per Sample
Midge larvae and pupae (*Chironomus* group)	63	7.0	707	33.7	770	25.7
Phantom midge larvae (*Chaoborus* group)	36	4.0	938	44.7	974	32.5
Alder-fly larvae *Sialis* (*Neuroptera*)	28	3.2	18	0.8	46	1.5
Scuds (Shrimp)	126	14.0	0	0.0	126	4.2
Snails & clams	68	7.5	0	0.0	68	2.3
Bristleworms (Oligochaetes)	68	7.5	402	19.1	470	15.6
Miscellaneous	16	1.8	0	0.0	16	0.5
Total and averages	405	45.0	2,065	98.3	2,470	82.3

*Based on a total of 30 quantitative samples taken with an Ekman dredge as follows: 9 in bottoms 25 feet or less in depth and 21 in bottoms over 25 feet in depth. Types of bottoms sampled were as follows: 23 from silt, 3 from mud, 3 from gravel, and 1 from decayed debris.

In quantitative food studies reported by Needham and Hanson (1935) from mountain lakes in California, an interesting comparison can be made. As noted just above, the average number of organisms found per Ekman dredge sample was 82.3 in Fish Lake. In west slope Sierra lakes these workers found an average of only 26 organisms per Ekman, and in east slope California lakes this increased to an average of 66 per sample. However, lakes in the Klamath River watershed showed an average of 150 per sample or nearly twice as many as the Fish Lake samples. Ziesenhenne (1937) reports from a two-year survey of lakes in the Williamette National Forest in Oregon, that in one Ekman sample taken in Lower Erma Bell Lake a total of 626 midge larvae and papae were taken. He notes that this was the richest sample obtained and does not give any average figure for lakes of the Williamette Forest as a whole. He reports removing (op. cit.) over 890 alder-fly larvae from the stomach of one eastern brook trout with many of the larvae still alive and active.

The dangers of overstocking, of course, are much greater where fish foods are scarce. This is a real danger, for example in high Sierra lakes in California. If but few fish are removed annually by anglers, and if good spawning conditions exist, these conditions may result in the production of thin, emaciated specimens which offer both poor sport and food. In the case of Fish Lake the fish caught were observed to be in excellent condition, plump and deep bodied, and, here at least, the food supply is apparently adequate to support an extremely heavy fish population.

Fishes Present

Three species of fish are native to Fish Lake. These are rainbow trout, Salmo gairdnerii, black-sided dace, Apocope oscula nubila, and bullhead, Cottus gulosus. Eastern brook trout, Salvelinus fontinalis, according to Oregon Game Commission records were first planted in Fish Lake in 1935. The dace and bullheads probably furnish much food for trout in Fish Lake by serving as converters of smaller plankton foods into fish flesh.

In the examination of the stomach contents, it was noted that practically every fish had eaten numbers of water-fleas (Cladacerans), Daphnia pulex and Daphnia longispina. Following these, the organisms, listed in the order of their importance in numbers were: Bloodworms (Chironomus), mayfly adults and nymphs, scuds or shrimp, caddicefly adults, pupae and larvae; water mites; snails (Physa), and various other aquatic organisms.

CATCH RECORDS

From the above discussion it is evident that excellent environmental conditions exist for trout in Fish Lake. When it is recalled that Fish Lake lies six miles from the end of the road it is rather surprising to find a glers caught a total of 5936 trou in the 1937 season (Table 2). The catch per angling hour was 4.18 fish (Table 3). No wonder fishermen were willing to trek up the steep, six-mile trail to the lake where they were almost certain to be well rewarded for their efforts. Four fish per hour is good fishing in anybody's language. In contrast with this figure, Needham (1937) found the average catch from boats on Convict Lake to be 0.21 fi h per angling hour. On this lake an angler of average ability, therefore, would have to fish about five hours to catch one fish. Convict Lake is easily accessible by road, intensively

fished, and these features are clearly reflected in the great reduction of fish caught per angling hour compared to Fish Lake. Later catch record work on Convict Lake in May and early June, 1938, (unpublished) showed a catch per angling hour of approximately 0.5 fish, covering both fishing from shore and in boats.

Total catch records taken on Squaw Creek by Mr. A. C. Randle (unpublished) of the U. S. Forest Service in 1937 showed 2.4 fish caught per angling hour. Squaw Creek is tributary to the Pit River in northern California, and is somewhat inaccessible, by a narrow and rough mountain road. Here again it is evident that inaccessibility and large catch per angling hour tend to go hand in hand, as in the case of Fish Lake.

Eschmeyer (1935, 1936) reports a gross catch per hour of 1.72 fish in 1935, and 1.27 per hour in 1936, from catch records taken on Fife Lake in Michigan. This is a typical, easily accessible, warm-water lake containing bass, perch, bullheads, bluegills, northern pike, and other common warm-water species. Compared to a return of 4.18 trout per hour from Fish Lake, the excellence of the angling in the latter water is further emphasized.

It is of interest to note here that a total of 558 catches were made in Fish Lake in 1937. The average number of fish per catch was 10.65.*

Species Caught

Out of the total 5946 fish reported caught, 5878 or almost ninety-nine percent were native rainbow trout and only sixty-eight were eastern brook trout (Table 2). It is evident that the rainbow are bearing the brunt of the angling burden by the aid of natural propagation. As noted below, the only recent planting of rainbow trout was in 1937 and these fish could not have possibly become big enough to enter angler's catches in that same year. Rainbow may have been planted in early years but earlier stocking records for Fish Lake, if any, have not been found by the writers. In any case, these data indicate that Mother Nature is doing a fine job. If these facts were not available, undoubtedly the artificial plants made would receive full credit for the excellent angling in Fish Lake. Both this and other preliminary catch record work seem to raise two major questions; how can we best use the hatchery product, and how can we aid nature to maintain her present contributions or to increase them?

It is of interest here to compare recent planting records with the catch records. The stocking records show that the following fish were planted in Fish Lake:

Year	Number	Species
1934	20,000	Cutthroat
1935	20,000	Eastern brook
1936	20,000	" "
1937	20,000	Rainbow

*The creel limit on Fish Lake is "15 pounds and one fish but not to exceed 15 fish in any one day, or 30 pounds and one fish but not to exceed 30 fish in any 7 consecutive days". Of the 558 catches made, 246, or 44 percent, reported limit catches of 15 fish.

A total of 40,000 eastern brook were planted in 1935 and 1936, yet only sixty-eight of this species were reported caught. Assuming then, that the fish planted in both years had grown sufficiently to enter the catches in 1937, a ratio of fish caught to fish planted would be 1:588. In other words, one eastern brook was caught in the 1937 season for every 588 planted in 1935 and 1936. Since fish planted in Fish Lake must be packed in on horseback, it is feasible to carry in only small fingerlings. All fish planted have been small. Hence, the assumption that the eastern brook planted in 1936 had achieved large enough size in one year after planting may be in error. If ratio of fish planted to fish caught be based only on the 1935 plant, then the ratio becomes 1:294. It would involve obvious error to assume that these figures show accurate survival rates of planted fish. If total catch records were obtained each year since planting, and covered the actual life span of the fish, and provided the outlet was screened to prevent them from leaving the Lake, then it would be possible to determine survival in terms of fish killed by anglers.

No survivors of the cutthroat planted in 1934, were reported caught in 1937.

Catch by Months.--Of the total 5946 fish reported caught, 2290 or 38.5 percent were taken in the month of July. (Table 2) These were taken in 208 separate catches. Only 842 trout or 14.2 percent of the total were taken in June. August showed the second highest number of fish, 1408 or 23.7 percent. May and September produced the least fish as would naturally be expected as the former month covers the early portion of the fishing season and the latter the end of the season when fewer anglers get into the Lake.

Table 2
Summary Fish Lake Catch Records
by Months

Month	Number of Catches	Number and species caught		Total Number of Fish	Per Cent
		Rainbow	Eastern Brook		
1937					
May	64	703	10	713	12.0
June	62	819	23	842	14.2
July	208	2,272	18	2,290	38.5
Aug.	154	1,399	9	1,408	23.7
Sept.	70	685	8	693	11.6
Total	558	5,878	68	5,946	--

While the greater part of the rainbow trout were taken in July and August, most of the eastern brook (thirty-three out of sixty-eight) were taken in May and June. This is not surprising as it is well known that the fishing for eastern brook often becomes poor in midsummer after water has warmed up.

In Table 3 is shown the catch per angling hour, calculated from total hours and total fish caught by months. As noted above, the average catch per angling hour (unit of effort) was 4.18 fish over the entire season. Using the catch per angling hour then as a criteria upon wuich to judge the excellence of the fishing each month, it is evident that the most fish were caught per hour in July. This month an hour's fishing produced almost five fish (4.86)... May was poorest at 3.96 per hour while other months varied between this figure and that shown for July. The average length of the fishing period was slightly over 2.5 hours.

Table 3
Catch per Unit of Effort by Months

Month	Total Hours Fished	Total Fish Caught	Catch Per Angling Hour
May	180	713	3.96
June	206	842	4.08
July	471	2,290	4.86
August	396	1,408	3.55
September	169	693	4.10
Total	1,422	5,946	Av. 4.18

The excellence of the angling by months might be judged by the average number of fish taken per catch in each. However, that this would be in error is evident when it is remembered that such calculations do not take into consideration the amount of effort or hours that it took to catch the fish.

Most of the anglers who fished the Lake were dyed-in-the-wool expert trout fishermen who were willing to go to the trouble to hike the six miles into the Lake, and none were reported who failed to catch fish.

Catch by Sizes Taken--The average size of the rainbow caught was slightly over 9-1/2 inches. The average weight was 5 oz. or one-third of a pound.

Since the length of the largest fish in each catch was recorded it is possible to show the average maximum length of fish reported by two-inch size groups. Out of a total of 558 catches, exactly 400 showed the maximum length of the largest fish taken to fall into the 10" to 11.9" size group. In the next largest size group, 12" to 13.9", 115 fish were recorded. The 14"-15.9" size group showed only 16 fish, while the 16"-17.9" group had only 10 fish. Only fifteen fish, one in the 6"-7.9" size group, and 14 in the 8"-9.9" group, were reported as the largest fish in fifteen catches.

Only two larger fish, both rainbows, were taken. One was 21.5" long and the other was 23.5" in length. The latter weighed 3.5 lbs. and, believe it or not, was caught by a lady angler from Portland, Oregon. Besides this big one she took nine others in only 2-1/2 hours trolling from a boat on July 27th.

Sizes of Eastern Brook Caught

Actual measurements were recorded for sixty-three of the sixty-eight eastern brook trout caught. If these are segregated by two-inch length groups, thirty, or almost fifty percent, fall into the 8"-9.9" size group. Nine fish fell in the 10"-11.9" group, while sixteen fell into the 12"-13.9" group. Only four were between fourteen and eighteen inches in length and only four were under eight inches. The average length (tip to tip) of the eastern brook measured was 10.38 inches, or about one-inch longer than the average size of the rainbow caught.

MISCELLANEOUS OBSERVATIONS

There are several other aspects of the data here presented that lend additional interest. One of these relates to production in terms of numbers and pounds of fish caught by anglers. As stated earlier, Fish Lake has an area of approximately ninety acres. The total 5,946 trout caught weighed a total of 1,821.56 pounds. Therefore, anglers removed an average of slightly over sixty-six fish per acre of water surface. Similarly, on a poundage basis, they removed roughly twenty pounds of trout per acre. Again the astounding fact is brought home of the very surprising amount of fish that such a small body of water will produce. This does not include the enjoyment, recreation, and rest afforded anglers and obtained as a by-product in the course of their stay on the Lake. Whether Fish Lake can continue to produce at its present rate or whether the 1937 records be high, low, or average remains to be seen. Facts such as these are bound to point the way to sound management methods.

Another point of interest is the angling methods and their comparative success as shown by the records. Summarized below is a rough listing of the methods and the success obtained.

Fishing Method	Number Trout Caught	Per Cent
By trolling; either spinners, worms, flies, etc.	5,312	89.3
By fly fishing	377	6.3
By miscellaneous (non-classifiable)	257	4.3
Total	5,946	—

Trolling was the dominant method used and accounted for almost ninety percent of all fish caught. Fly fishing, on the other hand, produced only slightly over six percent. These figures may be considered as only rough approximations.

Oregonians are prone to claim that the native sons of the golden state of California come up to Oregon in the summer for fishing, and return with copious quantities of fine trout. Of anglers who partook of the excellent fishing afforded by Fish Lake, eighty-eight percent reported that they were residents of Oregon, and eleven percent were resident in California. Now it is quite a concession for a Californian to go outside his own state after either scenery or angling, and needless to say, Oregonians should be duly complimented by the number that did appear at Fish Lake. One lone angler reported New Jersey as his residence. He must have been lost!

PLANS FOR FUTURE WORK

It is planned to continue to collect detailed records on the size and quality of the annual fish crop at Fish Lake each year as long as a guard is stationed at the Lake or until the data which are collected ceases to be of sufficient value to warrant the effort. The methods of obtaining and recording the data during 1938 and subsequent years will be slightly modified. The actual weight and length of each fish caught will be recorded by species and summarized by two-inch size groups. In the future fish will be measured from the tip of the snout to the end of the vertebral column, i.e., standard length, instead of from tip to tip as was done in 1937.

Arrangements have been made with the Oregon Game Commission to plant 10,000 marked two-inch rainbow trout in the Lake this year. It is desired to mark either all or a good sample of the fish which are planted as long in the future as creel census data are obtained. The marking of artificially planted fish will afford a splendid opportunity to compare the number of naturally propagated trout that are caught with the number of marked trout planted from hatcheries. It also will permit determination of the survival rate of hatchery reared trout to anglers' creels. Marking studies open up a whole field of possibilities for obtaining basic data. The extent to which these opportunities will be realized will depend of course on availability of funds and personnel to carry on more technical phases of the studies.

SUMMARY

1. Catch records taken on Fish Lake, a ninety acre lake lying at the headwaters of the South Umpqua River in Oregon, showed a total of 5946 trout caught in 558 catches in the season of 1937.

2. Of total trout taken, 98.85 percent were native rainbow, and 1.15 percent were eastern brook trout. Rainbow are evidently maintaining themselves by natural propagation, as the first recorded plant of this species was made in 1937.

3. The catch per angling hour was 4.18 fish. The average number of fish per catch was 10.65.

4. Total weight of trout caught was 1,821.56 lbs. Production to anglers' creels was calculated at approximately 20 lbs. per acre of surface water area. Number of trout caught per acre was 66.

BIBLIOGRAPH

Eschmeyer, R. W.

1935. Analysis of the game-fish catch in a Michigan Lake. Trans. Amer. Fish. Soc., Vol. 65, pp. 207-223.

1936. A second season of creel census on Fife Lake. Trans. Amer. Fish. Soc., Vol. 66, pp. 324-334.

Needham, P. R., and H. A. Hanson

1935. A stream survey of the waters of the Sierra National Forest, California, 1934. U. S. Bur. Fish. 54 pp. (Mimeo.)

1937. Methods of measuring anglers' catches in inland water. Copeia, No. 1, Apr. pp. 41-48.

Roth, A. R.

1937. A survey of the waters of the South Umpqua Ranger District, Umpqua National Forest. U. S. Dept. Agr., Forest Service, 42 pp. (Mimeo.)

Ziesenhenne, Fred

1937. Lake survey of the Williamette National Forest, U. S. Dept. Agr., Forest Service, 32 pp. (Mimeo.)

A CORRECTION

IN THE FIRST paragraph on page six of THE PROGRESSIVE FISH CULTURIST, issue number 39 (June-July, 1938), it is erroneously stated that in the process of treatment described as salting, one ounce of finely ground salt is dissolved in each 150 cubic inches of water contained in the trough to be treated. This should read "one ounce of salt for each 60 cubic inches of water".

It is recommended to those anticipating any occasion to refer to this article describing treatments that they change this number immediately in their copy of THE PROGRESSIVE FISH CULTURIST for the amount of salt as originally printed will do little or no good in combatting external parasites on fish.

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COMMENTS FROM OUR READERS

IMPROVED SHIPPING FACILITIES RECOMMENDED

EDITOR, THE PROGRESSIVE FISH CULTURIST:

In my trips over the country, on vacation and otherwise, I visit as many hatcheries as possible. Judging from what I have seen very little has been done to improve the tank and shipping places at the hatcheries. Some places have tanks out in the open, some have them in a shed, most places do not have a suitable table for sorting and counting fish, and I have seen only one hatchery with a leading chute where a truck can be driven in and the fish loaded without balancing a tub of water all the way from under your arms to over your head.

On the attached sketch I have drawn plans for a building that in my opinion would be a vast improvement over the ones now in use at most hatcheries. Following is a list of the good qualities of the plan.

1. The distribution and handling of fish is done sometimes when the weather is hot and again when it is cold enough to form ice. Under these varying conditions an enclosed building with plenty of light is to be preferred over an open shed or being out in the open.

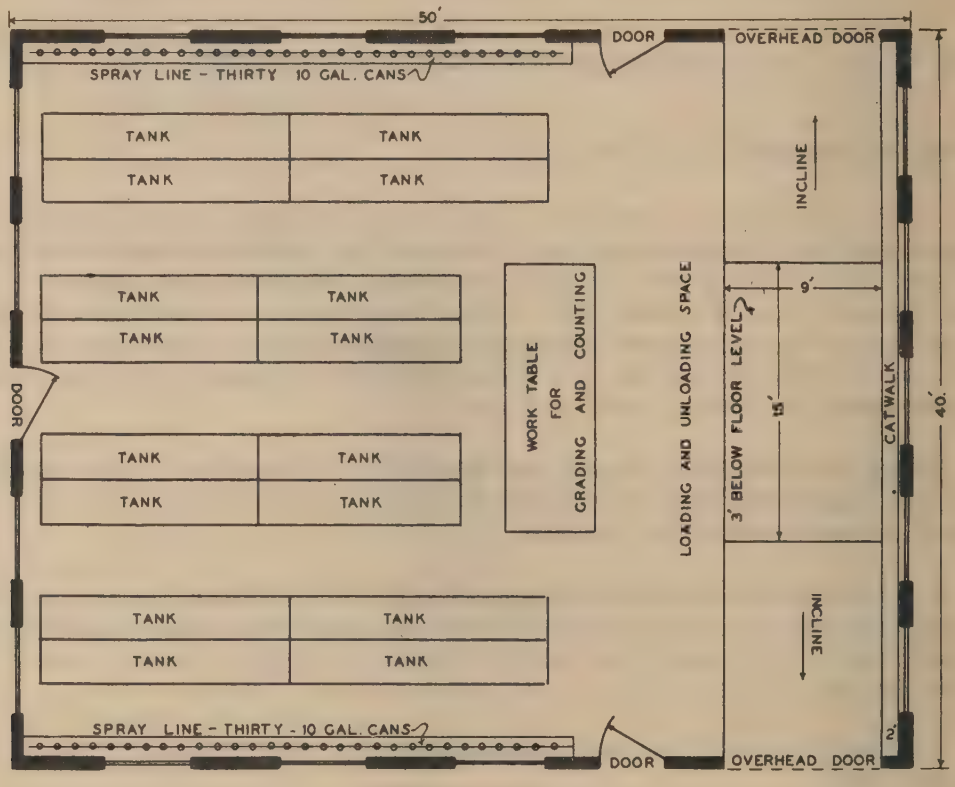
2. Sufficient tank room should be available to take care of the bass from a 6 or 8 acre pond.

3. There should be spray lines under which you can hold 60 ten gallon cans. There are times when a truck load of fish must be held in the cans for a few hours until the truck arrives.

4. A sorting and counting table should be located in the center of the working area. The table should have a water tight top, a drain, and a one inch edge rail, should have a capacity of at least 8 No. 2 tubs, and should be about 26 inches in height so that with a tub on top it is the correct height for a man to work. Pipes should be arranged so that a spray of water can be directed into each tub to temper fish or add fresh water while sorting and counting. Near the table there should be a two inch water connection and valve with a fire hose to fill barrels, cans, and tanks, for both bringing in fish from the field and for filling containers to ship fish out.

5. A loading pit of sufficient width and depth to accommodate ordinary trucks and make putting fish into containers much easier and faster. This pit should have

incorporated into its construction a screened drain so that if at any time it was needed, it could be filled with water and converted into a retaining pond for fish. Under average conditions fish brought in from the field would be unloaded along side of the sorting table where they would be cleaned up and counted into the tanks. When fish were shipped out they would be carried from the tanks to the truck in the pit.



FLOOR PLAN FOR

TANK AND SHIPPING BUILDING

SCALE - 1"=10'

We move fish from the ponds to the buildings in barrels on a truck. Sometimes when temperatures are right we catch fish much faster than it is possible to clean them up and count them. Under these conditions the pit could be filled with water and the fish placed in there and removed and counted later. Ordinarily the fish are held in cold water two or three days before shipping. This would give time to count the fish out of the pit-pond and have it available for the trucks when distribution was started.

The dimensions on the sketch are just arbitrary but to have a shipping building where efficiency is considered all the equipment described must be available. If the plan has sufficient merit to warrant publication or distribution to parties wanting plans for a shipping building you may pass it on.

Joe Hogan,
Lonoke Hatchery,
Lonoke Arkansas.

SEINE HANDLES FOUND USEFUL

EDITOR, THE PROGRESSIVE FISH CULTURIST:

One of the things which we value most at our plant is a pair of seine handles, shaped like a large "T".

These "T's" are built of Idaho white pine wood 1½" square. The lower or vertical part of each "T" is a piece 12' long, the horizontal piece is 4' long, wire struts 4' long are joined to the outer ends of the horizontal piece and then secured to the main stem or vertical piece. Screen door stays with turnbuckles make excellent struts.

The resulting "T" is rigid and durable as well as light and easily handled.

A short seine of proper mesh may be attached between these "T" handles. Such a seine may then be hoisted by two men and dropped 12 or 14 feet from shore into water of any depth and drawn to shore rapidly. The enclosed snapshots may serve to illustrate how such a seine is used.

A seine equipped with "T" handles has many advantages. It saves getting into waders many times. Fish may be seined from a pond quickly and easily and the water needn't be roiled. Such a seine is useful in salvaging fish stranded where the mud is deep. No tracks are left for fish to collect in by wading seiners because all seining is done from the shore.

We use this seine for collecting stray schools of fry, transferring fingerling fish from over populated ponds to those less densely populated, and collecting random samples of fish, either in our ponds or from streams.

If the fish in a pond are in distress on account of a lack of dissolved oxygen in the water, they usually collect around the pipes carrying fresh water to the pond. Such fish may easily be seined up and transferred to other water without entering the pond if a suitable seine equipped with a set of the aforementioned handles is used.

Such seine handles are simple and inexpensive to build and we would not be without them. The worth of these handles and their simplicity makes me wonder if they are not used elsewhere. Ours are the first we have seen and it would make us very happy if we could add a little to the general knowledge of the practical fish farmer.

John G. Sullivan, Foreman,
State Fish Farm #5,
Bucyrus, Ohio.

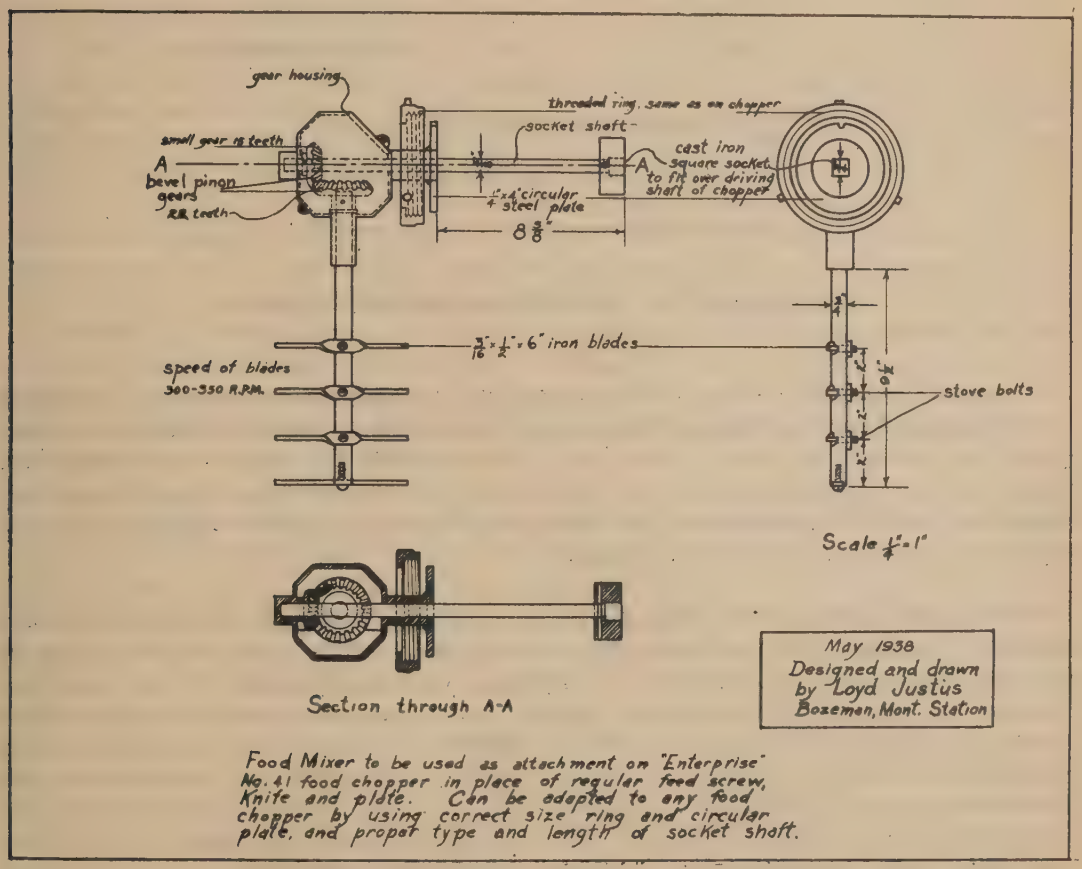
FOOD MIXER ATTACHMENT FOR GRINDING UNIT

EDITOR, THE PROGRESSIVE FISH CULTURIST:

The accompanying drawing shows a fish food mixer developed at this station for mixing feed prior to feeding, and also for mixing dry feed with fresh liver before putting it through the blower. The drawing shows construction details of the mixer, but a little explanation of how it works may be helpful.

As all fish hatcheries are equipped with food choppers it was thought best to construct a food mixer that could be used as an attachement with these food choppers. Our chopper runs at a speed of about 440 R.P.M. As this was found to be too fast to run a mixer, the speed was reduced by constructing the mixer with a large gear and a small one running together. As shown on the drawing, the driving gear has 15 teeth and the driven gear (the one that turns the blades) has 22 teeth. This gives the mixer blades a speed of about 300 R.P.M., which is quite satisfactory although a speed of about 375 revolutions would not be too fast. Our electric motor is rated

at two horse power, but I believe that the mixer could be run with a less powerful motor. As stated on the drawing this type of mixer could very easily be adapted to any size chopper by using the correct size ring, and circular plate, and proper type and length of socket shaft.


gear housing
threaded ring, same as on chopper
socket shaft
small gear 15 teeth
A
bevel pinon gears
28 teeth
A
cast iron square socket to fit over driving shaft of chopper
1" x 4" circular 4 steel plate
8 3/8"
3/16" x 1/2" x 6" iron blades
speed of blades 300-350 R.P.M.
stove bolts
Scale 1/4"=1"
Section through A-A
May 1938
Designed and drawn by Loyd Justus
Bozeman, Mont. Station
Food Mixer to be used as attachment on "Enterprise" No. 41 food chopper in place of regular feed screw, Knife and plate. Can be adapted to any food chopper by using correct size ring and circular plate, and proper type and length of socket shaft.

We have at this station a mixer which is constructed essentially the same as the drawing. It is used as an attachment for our food chopper and fits in place of the regular feed screw, knife and plate. It can be put on or taken off in about one minute. We leave this mixer attached to the chopper except during the time that feed is being run through the chopper. To use the mixer we put the proper amount of feed to be mixed in a bucket, turn on the switch and hold the bucket of feed so that the blades of the mixer revolve through the feed, thoroughly mixing it. Hand mixing of dry feed as done heretofore has been a slow and laborious task and it has been hard to get a fine even mixture that feeds well or that would run through the blower smoothly. With the use of the power herein described, a very good mix can be had in a short time without any hard work.

Not only does the mixer work well with dry feeds but is very useful in the mixing of fresh meat feeds, especially the more fibrous varieties or food to be finely mixed for feeding very small fish. Large quantities of fresh feed can be mixed in a very short time with little effort and a better mix is assured than if done by hand.

Lloyd Justus
U. S. Fisheries Station
Bozeman, Montana.

NOTES AND NEWS

ESTABLISHMENT OF FISH CULTURAL SERVICE IN BRAIIL

DURING THE month of June 1938 the Ministry of Agriculture of Brazil announced the organization of the "Service Nacional de Piscicultura" in Rio de Janeiro, to develop the breeding of native fresh water fishes and at the same time to study the biological and limnological problems relating to aquiculture. According to the announcement the central laboratory of the new service will be located temporarily in the Departmento Nacional de Produccao Animal.

The plans call for the immediate establishment of two fish cultural experiment stations, one in the State of Sao Paula on the Mogy-Guassu River and the other in Rio Grande do Sul. Dr. Rudolph von Ihering, formerly Director of the Commissao Technica de Piscicultura do Nordeste, Ceara, Brazil, has been placed in charge of the Service Nacional de Piscicultura. He was succeeded at Ceara by his former research assistant, Dr. Pedro de Azevedo, who will continue the excellent researches in the northeastern section begun by Dr. von Ihering. The new national fish cultural service will have the cooperation of Dr. Otto Schubart, a German zoologist, who for several years was responsible for the now discontinued Laboratorio de Ichthyologia in Pernambuco. The staff will also include a limnologist, probably chosen from the United States, to fill the position formerly held by Dr. Stillman Wright, who was originally connected with the U. S. Bureau of Fisheries and who has now returned to the United States where he has resumed his studies with th Federal Bureau. There will also be eight Brazilian biologists and veterinarians.

The chief problem of the national fish cultural service in the beginning will be the raising in large quantities of various promising species of native fishes of the family Characidae, such as the piracanjuba, piapara, and pacu, particularly those which are herbivorous; and the mandy (Pimelodus clarias) and the sofia (Pachyurus) which are insectivorous. General investigations will include the various anatomical, physiological, and environmental questions on which rational fish culture is based. In these latter studies Dr. von Ihering appeals to the scientists of other countries

for assistance, pointing out that the aquatic flora and fauna of the region require detailed, systematic study. In view of the relatively small number of specialists in the great variety of orders in both kingdoms, the fish cultural service will welcome an opportunity to forward properly preserved collections of zoological and botanicals material to scientists abroad, with the understanding that any complete set of the classified specimens be returned for deposit in the national museum in Rio de Janeiro.

In a private communication to the Editor of the PROGRESSIVE FISH CULTURIST, Dr. von Ihering, perhaps facetiously, offered his thanks to our journal for services rendered in connection with the establishment of the Servico Nacional de Piscicultura. He referred particularly to the article entitled "Fish Culture is Big Business in the United States," by Swepson Earle, published in July 1937 (No. 31), in which the magnitude of the fish cultural undertaking and a map showing the distribution of nearly 500 fish cultural stations in the United States were presented. While it can scarcely be argued seriously that this article was a deciding factor leading to the establishment of such service in Brazil, it cannot be denied that the development of so far-reaching an undertaking requiring the vast expenditure of public funds, the general success attained in the restoration and maintenance of supplies of food and game fishes in our own waters, and the popular approval of such activities in the United States, must serve as an object lesson to other countries which through national development are facing conservation problems similar to our own.

The fish culturists of America salute their new brothers in the Craft in Brazil, trusting that they will adopt the good in the North American system of fish culture, profit by our mistakes, contribute to the science and art of fishery management, and push on to greater successes in this field than have ever before been realized.

REVIEWS

THE MAINTENANCE AND CARE OF FISHING WATERS

Rohler. Ernst. 1937. Die Erhaltung und Pflege der Fischgewasser. Handbuch der Binnenfischerei Mitteleuropas. Band VI. Lieferung 4. 59 illustrations. pp. 343-416

Dr. Rohler brings together the findings of fifty European authors who have written on this comparatively new field of fisheries investigation. His book deals chiefly with the methods of eliminating swamps, weed-beds and bogging from inland waters. Or, in other words, methods are presented which help prevent the natural tendency of the land to encroach upon and consume lakes and ponds. This phenomenon he calls "Verlandung".

This information has practical application to the lake frontages of summer homes where encroachment of reeds, weed-beds, and bogging have destroyed bathing and fishing

Designs of apparatus for cutting out reeds, weed-beds, sphagnum, and digging out shore mud and other nuisances are given in detail.

Different types of pond and lake "Verlandung" are illustrated, evils pointed out and suggestions made for the production of more water area for fish production and in addition open water maintenance.

The author gives some interesting values that have been placed on the products of shore areas and their commercial utilization. The exploitation of these products for farm use has proved valuable. The weeds have been found very nutrititious to farm animals when properly dried. Reeds have been used as straw for weaving and in fiber industries.

This reviewer recommends this booklet to fish culturists, resort owners, and sporting clubs as full of new ideas on care and maintenance of shallow water areas of ponds and lakes.

Arthur D. Hasler.

PROGRESS REPORT OF TROUT FEEDING EXPERIMENTS, 1937

J. H. Wales and Myron Moore, Bureau of Fish Conservation, California Division of Fish and Game. California Fish and Game, Vol 24, No. 2, April, 1938, pp. 126-132.

ABSTRACT

The principal objects of experiments conducted in 1937 with trough-reared fingerlings were (1) to determine the minimum percentage of fresh meat for practical hatchery feeding; (2) to determine if possible some practical methods of feeding large numbers of fingerlings on a combination with a high meal content; and (3) to determine what pathological changes might occur when trout had been fed on dry meals without any fresh meat supplement. Owing to unexpected difficulties which arose during the course of the experiments, it was necessary to deviate from the original plans to some extent.

Brook, brown, and rainbow trout fingerlings were used in experiments to determine the minimum proportion of liver which could be used with meals in the producing hatchery. Salmon carcass meal was first used, but since this contained bone fragments which killed a number of the fingerlings a vacuum dried sardine meal was substituted. It was found that 25 percent liver by weight is a satisfactory minimum providing the combination is properly prepared and fed. However, fingerlings smaller than 25 per ounce cannot be fed meal pellets and no satisfactory method was found for feeding high meal combinations to these small fish. Fingerlings larger than 25 per ounce can be fed straight meal pellets twice a day and meat once. Unless some method can be developed whereby liver and meals can be combined and fed without serious water pollution, it will be impracticable to feed small fingerlings more than 25 percent meal with the balance liver.

Diets of 100 percent meal (sardine and dry skim milk) or of 90 percent meal and 10 percent liver (by weight) proved inadequate when fed to brown and brook trout fingerlings. The trouble undoubtedly lies in the deficiency of the fresh meat factor sometimes called "Factor H". On such a diet symptoms of two types were exhibited. In one, the fish lost appetite, became dark, sluggish, and emaciated, and developed hyaline casts in the kidney tubules. In the second, large and apparently healthy fish suffered a nervous disorder, losing equilibrium and dashing about the troughs. About 75 percent so affected recovered.

Beef heart, beef liver, and beef lungs were fed as straight diets to 3 groups of rainbow fingerlings. It was found that there was very little difference in health and growth and that the red cell count remained approximately the same in each.

Approximately 3,000 yearling brook trout were fed commercial dog food without fresh meat additions for six months. It is assumed that the fish also obtained a certain amount of aquatic and aerial organisms. In five months the fish had become seriously anemic and by the end of six months losses were so heavy that it was necessary to change the diet to beef liver. After two weeks on the liver diet the mortality ceased.

R.L.C.

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